PERFORMANCE ANALYSIS OF HIGH RESOLUTION IMAGES USING INTERPOLATION TECHNIQUES IN MULTIMEDIA COMMUNICATION SYSTEM

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ABSTRACT

This paper presents various types of interpolation techniques to obtain a high quality image The difference between the proposed algorithm and conventional algorithms (in estimation of missing pixel value) is that if standard deviation of image is used to calculate pixel value rather than the value of nearmost neighbor, the image gives the better result. The proposed method demonstrated higher performances in terms of PSNR and SSIM when compared to the conventional interpolation algorithms mentioned.

KEYWORDS

Interpolation, Bicubic, Bilinear, Nearest Neighbor, PSNR, SSIM

1. INTRODUCTION

Low bandwidth and limited channels are one of the most challenging issues that every nation in this world is facing. Since signals and data to be sent via a channel are available in huge amount and limited amount of spectrum is allotted to every nation, hence signal needs to be compressed at the transmitter and expand at receiver in order to send multiple data. This compression and expansion leads to distortion of signals and sometimes even leads to false reconstruction at the receiver side. Thus the performance of system decreases and this also hinders in smooth operation of the system. If the channel is wireless the situation even becomes worse. Different amount of noise gets entered into the channel and try to deteriorate the signal. Sometimes the signal is even lost while traversing. If a digital image is sent via a wireless channel it has to be compressed at the transmitter because of limited channels. At receiver it may get distorted due to the presence of noise and during image expansion it might get deviated from its original form. Some features of images are hardly detectable by an eye so they should be often transformed before display. Image enhancement is a digital processing method which does its best to improve image vision and makes the image adapt to be processed by computer. It enhances some information inside the image selectively and restrains the other ones. To reconstruct or expand

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the image to get the original form, Upsampling or Interpolation of images is done. The paper is divided into six sections, section 2 gives a brief introduction about Interpolation Algorithms , section 3 covers some methods related to Interpolation , Section 4 discusses about our proposed method, section 5 gives us the result and discussion, and followed by the conclusion in section 6.

2. INTERPOLATION

Interpolation is the process of enlargement of images by creating new pixel values and filling the values appropriately by some algorithms[1]. Zooming requires new pixel values. Interpolation adds pixel values to this newly generated pixel according to the value of mean of near most pixels.

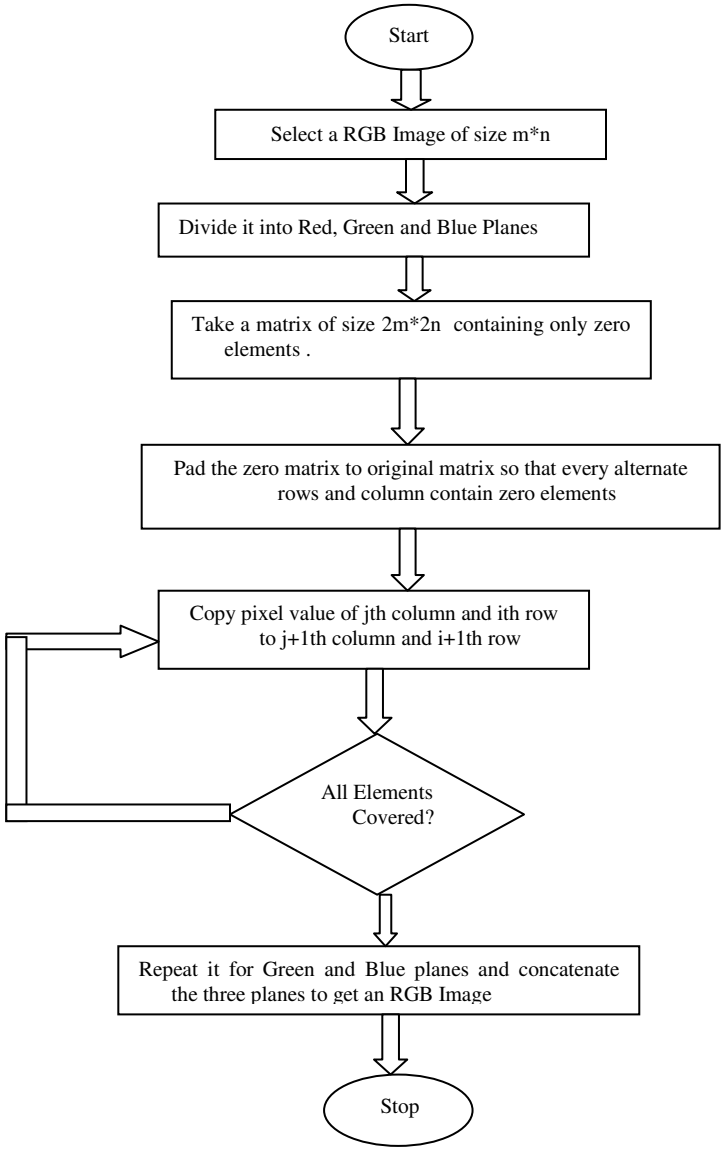
3. RELATED WORKS

Some conventional methods has been described below showing how Bicubic Interpoltion is more efficient.

3.1 Nearest Neighbor

One of the simplest interpolation algorithms is Nearest-Neighbor interpolation. In order to upsample or zoom an image Nearest Neighbor provides easiest way [2].Image enlargement requires two steps:- First is creation of new pixel locations and second is assignment of pixel values to those locations. This can be done by treating image as a matrix and creating new rows and columns by padding it with matrix having double the size of original image matrix and having only zero value so that every alternate rows or columns of resultant matrix contains zero as its pixel value. Next step is to assign the pixel value of the near most neighbor to the newly generated pixel. That is why this method of grey level assignment is called Nearest Neighbor Interpolation. The flowchart is shown below

3.1.1 Flow Chart



3.2 Bilinear Interpolation

The biggest drawback of nearest neighbor interpolation is that it cannot be used in high resolution zooming because it causes stair case edges. An interpolation technique that reduces the visual distortion caused by the fractional zoom calculation is the bilinear interpolation algorithm [3]. It is performed in one direction first (row wise) then again in other direction (column wise) . It uses four nearest neighbor of pixel whose value is to be determined. An image is selected and it is converted into matrix form. Another image of size 2m*2n is taken which contain zero elements. This matrix is padded with the matrix of image so that the resultan matrix contain zero elements in every alternate row and column. The weighted average of four pixels are calculated and the result is put into the newly generated pixel.The final pixel value v(x,y) of x row and y column is calculated as follows:-

$$\mathbf{v\,(x\,,\,y\,) = a - b * v(x,y\text{-}1) + c - d * v\,(x\,,\,y\text{+}1)}$$

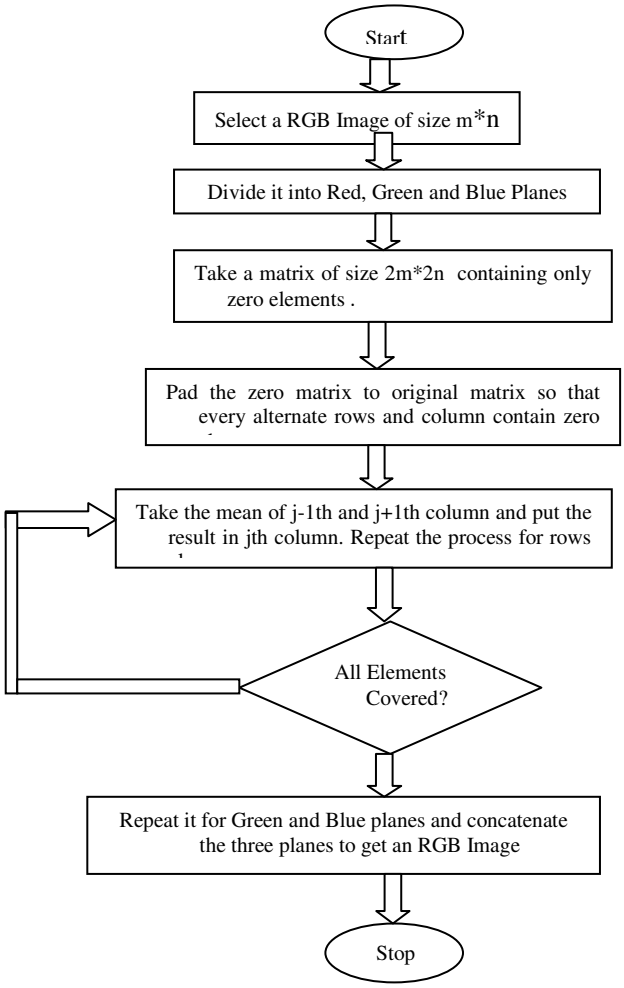
Where a = ((x+1) - x) / (x + 1)

b = (x – 1)

c = (x - (x – 1)) / (x + 1)

d = (x – 1)

3.2.1 Flow chart

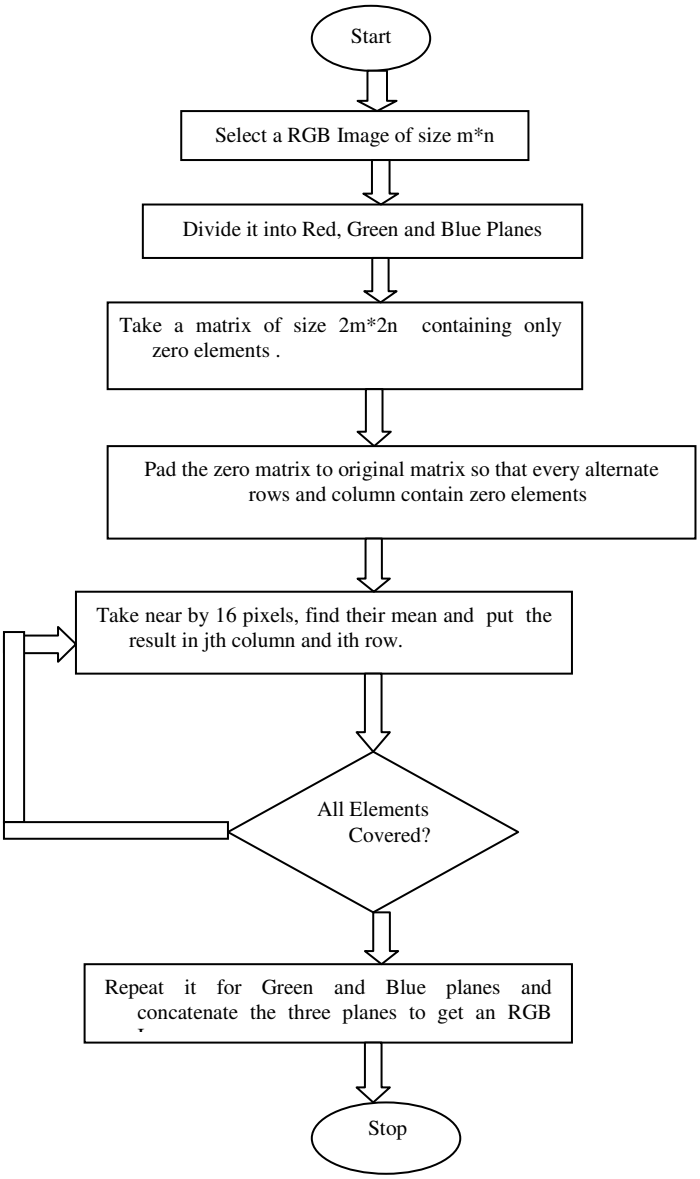


3.3 Bicubic Interpolation

High order interpolation schemes take more pixels into account. Second order interpolation is called as Cubic Interpolation as it uses a neighborhood of 16 pixels [4]. When speed is not an issue, Bicubic Interpolation is often chosen over Bilinear Interpolation or Nearest Neighbor in image enhancement. As compare to bilinear interpolation, which takes only 4 pixels (2x2) into

account, Bicubic Interpolation considers 16 pixels (4x4). Images resample with bicubic interpolation are smoother and b;ur is not formed even when image is interpolated many times. It fits two polynomials to the 16 pixels of the transformed original matrix and the centre of the new image pixel .This technique is very effective and produces images that are very close to the original image .

3.3.1 Flow Chart



4. PROPOSED METHOD TO CALCULATE PIXEL VALUE

Many advantages of Bicubic Interpolation technique make it suitable for its use in image processing applications. But it increases computational complexity and hence it is suitable only in 3D Graphics and Medical Imaging. For general purpose, Bilinear Interpolation is used as it is time saving method [5]. When noise is added in the image bilinear interpolation cannot remove it effectively. The proposed methodology, described below,will reduce noise more effectively than the bilinear interpolation [6].

4.1 Algorithm :-

The steps are as follows :-

1. Take the Color Image (RGB) 'Lena.jpg' of size 512*512 .
2. Add Salt and Pepper noise (or any other noise like Gaussian, Speckle etc) in it.
3. Decimate or Reduce the size of image to 256*256 pixels to convert it into a low resolution image.
4. Transmit the image at transmitter.
5. At receiver, create a matrix of size 512 *512 containing only zero elements and pad it with reduced matrix so that every alternate rows and columns of zoomed matrix is filled with only zero elements.
6. Take average of j+1th and j-1th pixel value column and put the result in jth column. Repeat the same process for rows also.
7. Take each 3*3 matrix within the enhanced matrix, find its Mean and put the result in the centre most point of the matrix. Repeat the process till all points are covered.

The above process [8], no doubt, reduces noise density but when the image is interpolated many times, it introduces blur in the image [7]. Thus in order to avoid blur, image is interpolated keeping in mind the Standard Deviation of the image. Standard Deviation depicts how much variation is there from the average value . A low standard deviation indicates that the data points are very close to the mean (also called expected value); a high standard deviation indicates that the data points are spread out over a large range of values. When a new pixel is created, it has to be assigned with the pixel value by choosing the values from the near most neighbor's pixel value. If mean of neighboring pixels are taken and to this mean if the standard deviation of image is added, than pixel value will be distributed more smoothly and uniformly within the image which is interpolated.

The steps taken to reduce the blur are as follows:-

4.2 Algorithm

1. Take the Color Image (RGB) 'Lena.jpg' of size 512*512 .
2. Decimate the image by a decimation factor of 4 and reduce the size of image to 128*128 pixels to convert it into a low resolution image.
3. Transmit the image at transmitter.
4. At receiver, generate a random variable , find its Probability Distribution Function and finally calculate the Standard Deviation of the image.

5. Take each 2*2 matrix within the reduced matrix, find its mean. To this mean, add the value of Standard Deviation and put the result in the centre most point of the matrix.

5. RESULT AND DISCUSSION

The resultant images obtained due to interpolation via Bilinear Algorithm and Proposed Methodology is given as follows :-

a. Bilinear Interpolated Image b. Image obtained by Proposed Method

Fig 1 Comparison of images obtained by a.) Bilinear Interpolation b.) Proposed Method

The resultant image obtained due to Proposed Methodology has less no is as compared to Bilinear Interpolated Image. The table of comparison for PSNR of Bilinear Interpolation and interpolation method by Proposed Methodology is drawn below for Decimation Factor of 2:-

SN NO	**Noise Density**	**PSNR of Bilinear**	**PSNR of Proposed Method**
1	0	31.1307	29.8789
2	0.05	27.409	27.4432
3	0.1	25.5191	26.2477
4	0.15	24.9956	25.4834
5	0.2	24.4309	24.974

Table 1 Comparison of PSNR values of Bilinear Interpolation and Interpolation by Proposed Methodology

The table indicates that as the value of noise decrease the value of PSNR in both methods decreases. The decrease in PSNR of Proposed Method is less than that of Bilinear Interpolation method.

PSNR of an image computes Peak Signal to Noise Ratio which determines how much is the ratio of signal power to that of noise Power [9]. It is given as

$$\mathbf{PSNR} = 20 * \log_{10} \frac{255}{RMSE}$$

where the value 255 is maximum possible value that can be attained by the image signal. Mean square error (MSE) is defined as

$$\mathbf{MSE} = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

$$\mathbf{RMSE} = \sqrt{MSE}$$

The Structure Similarity Index Measurement compares original image with reconstructed images based on its luminence, intensity and saturation. It depicts how closely reconstructed image is similar to original image when seen by human eyes.

The graph of SSIM for both interpolation algorithms is shown below:-

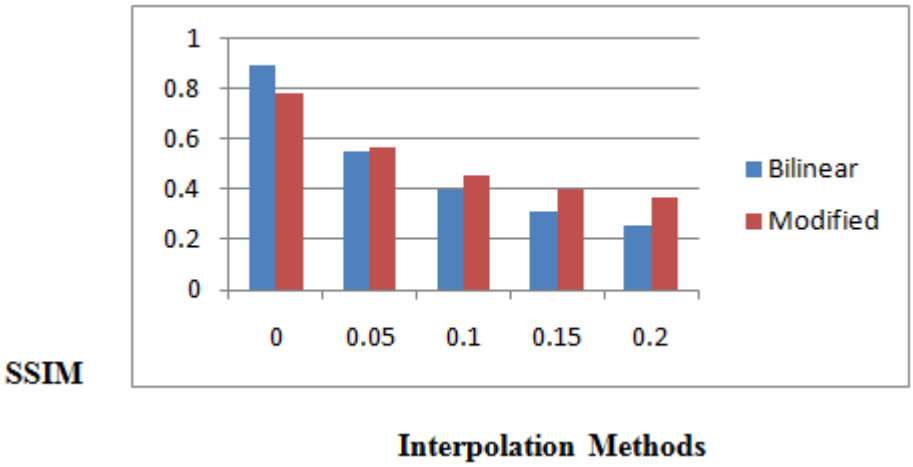
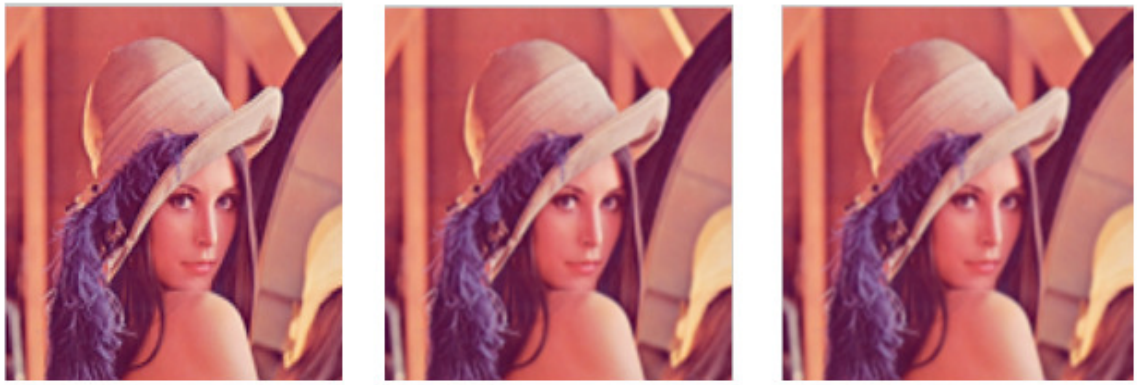


Fig 3 showing different values of SSIM w.r.t noise for Bilinear Interpolation and Algorithm by Proposed Method.

The above graph indicates that as the value of noise density increases SSIM value for Bilinear Interpolation decreases at a greater extent as compared to image obtained by Proposed Methodology.

In above process, noise is reduced but introduces blur in the image. So, again a method is proposed to reduce the blur by using standard deviation of the image. The resultant images are shown as follows:



a. Nearest Neighbor **b. Bilinear** **c. Image enhanced by Proposed Method**

Fig 3 shows the resultant images obtained by a.) Nearest Neighbor b.) Bilinear Algorithm c.) Proposed Method

The result shows stair case edges in Nearest Neighbor Interpolation, blur in Bilinear Interpolation and least blur in Proposed methodology.

The graph for PSNR for various interpolation methods is shown below:-

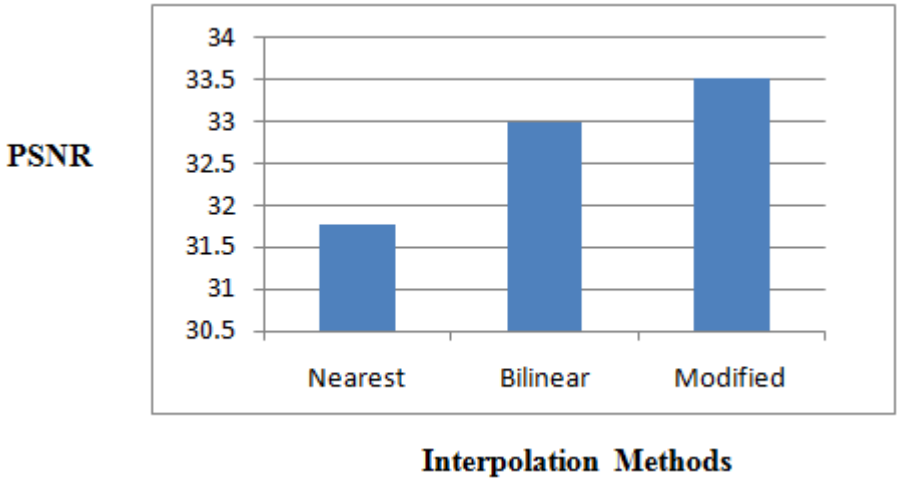


Fig. 4 Graph of PSNR for different Interpolation Algorithms

The above graph shows that the PSNR of image interpolated by proposed methodology gives the maximum value of 33.497 dB followed by Bilinear Interpolation (32.9748 dB) and Nearest Neighbor Interpolation (31.7644 dB).The output image due to Proposed Methodology can also be compared with conventional interpolation techniques using Structure Similarity Index Measurement. The graph obtained is as follows:

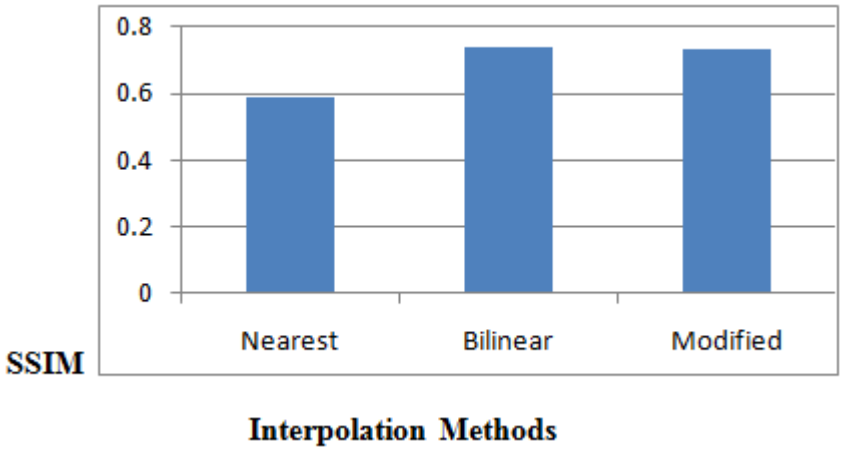


Fig 5 Graph of SSIM for different Interpolation Algorithm

The results obtained above indicate that both the images obtained by Proposed Methodology provide better results as compared to conventional interpolation algorithms**.**

6. CONCLUSION

Nearest Neighbor is the fastest and simplest method of interpolation, but leads to stair case Edges. Hence it is not used frequently. Bicubic Interpolation give good results but causes computational complexity. Hence it is used in 3D Graphics. Bilinear Interpolation is comparatively better than Nearest Neighbor but causes blur of images [10]. It can be concluded that images obtained by Proposed Methodology gives better result as compared to conventional interpolation algorithms.

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