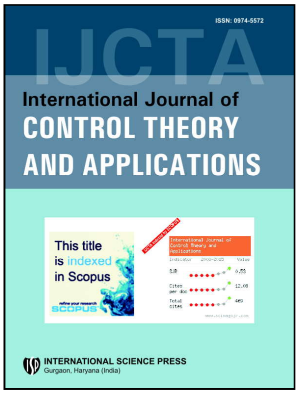

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Nearest Neighbor and Interpolation Based Super-Resolution

Abhijeet Shinde[1] and Sachin Ruikar[2]

[1,2] Department of Electronics Engineering Walchand College of Engineering, Sangli, India,
Emails: abhijeetshinde70@gmail.com, ruikarsachin@gmail.com

Abstract: Now a day's digitally the image interpolation techniques based on multi-resolution technique are being discovered and developed. All these techniques have importance due to their application in variety if field (medical diagnosis, geographical, satellite information) where fine and minor, accurate details are important. The determination of the values of a continuous function from discrete samples is known as interpolation. Image processing and computer vision applications of interpolation covers the areas of image magnification or image reduction, sub-pixel image registration, for correcting spatial distortions, image decompression, in image segmentation, restoration as well as others. There are many image interpolation techniques available,out of nearest neighbor, bilinear and bicubicconvolution are the most common, popular oneand will be talked about here. Our results show bicubic interpolations gives comparatively better results than nearest neighbor and bilinear interpolation.

Keywords: Nearest-Neighbor, Bilinear, Bicubic

1. INTRODUCTION

Interpolation is the process of estimating the values of a function at positions which lies between its samples. It achieves this process by simply fitting a continuous function through the discrete input samples. This allows input values to be assessed at arbitrary positions in the input, not just those defined at the sample points. It minimizes the bandwidth of a signal by applying a low-pass filter to the discrete signal. The interpolation process is one of the most important and fundamental operations in image processing. The quality of image is highly depending on which type of interpolation method is used. The interpolation techniques are basically divided into two major categories, that are deterministic and statistical interpolation techniques. Themain difference is that deterministic interpolation technique is it considerscertain variability between the sample points, like linearity in case of linear interpolation. Statistical interpolation techniques simply approximate the signal by minimizing the estimation error.

Digital image processing has earned a lot of importance in the recent year because of the advancements in graphical interfaces. Digital image processing is a subfield of digital signal processing which has made fabulous progress in varied domains, due to its various complicated applications. One can understood digital image processing as it's a method of processing an image using computer based algorithms to improve the varied aspects and quality of any particular image. Thus the one of the most important aspect of image processing and computer vision is the ways in which we can improve the quality of an image by using various techniques. Image interpolation is one such fundamental and important technique. Interpolations techniques determine obtain the values of a function at positions lying between its samples. In these paper the three basic interpolation techniques nearest neighbor, bilinear and bicubic are taken in order to compare its results.

2. PROPOSED ALGORITHM

2.1. Image Interpolation

One of the fundamental operation in image processing is the interpolation. The image quality is highly depend on the type of used interpolation technique. In many image processing and computer vision applications, thedigital images must be zoomed (increasing image scale)to enlarge image details and highlight any small structures present inside it. This is done by making multiple copies of the pixels in a selected region of interest within the image. Image interpolation occurs when we resize or distort our image from one pixel grid to another. So basically the interpolation is the process of transferring image from one resolution to another without changing the image quality. In simple words it is refers to the "guess" of intensity values at missing locations in an images. In Image processing field, image interpolation is very important function for doing zooming, enhancement of image, resizing, image restoration, image segmentation. During last decade various techniques of image processing are developed for example image restoration, filtering, compression, segmentation, etc. However image interpolation is less explored. So here I am take into account the performance of most commonly used interpolation techniques: nearest neighbor, bilinear, bicubic etc.

2.2. Nearest neihbor

It is a simplest interpolation technique among all. In this method each interpolated output pixel is assigned the value of the nearest sample point in the input image.

It is a simplest interpolation because of its ease of complexity. In this method, the fractional part of the pixel address is removed, and the pixel brightness value at the resulting integral address in the source image is simply copied to the zoomed image or scaled image. It should be noted that this method does not really interpolate values, it just copies existing values.

In the nearest neighbor algorithm, the intensity value for the point v(x, y) is assigned to the nearest neighboring pixel intensity f(x, y) which is the mapped pixel of the original image. The logic behind the approximation is as the equation below.

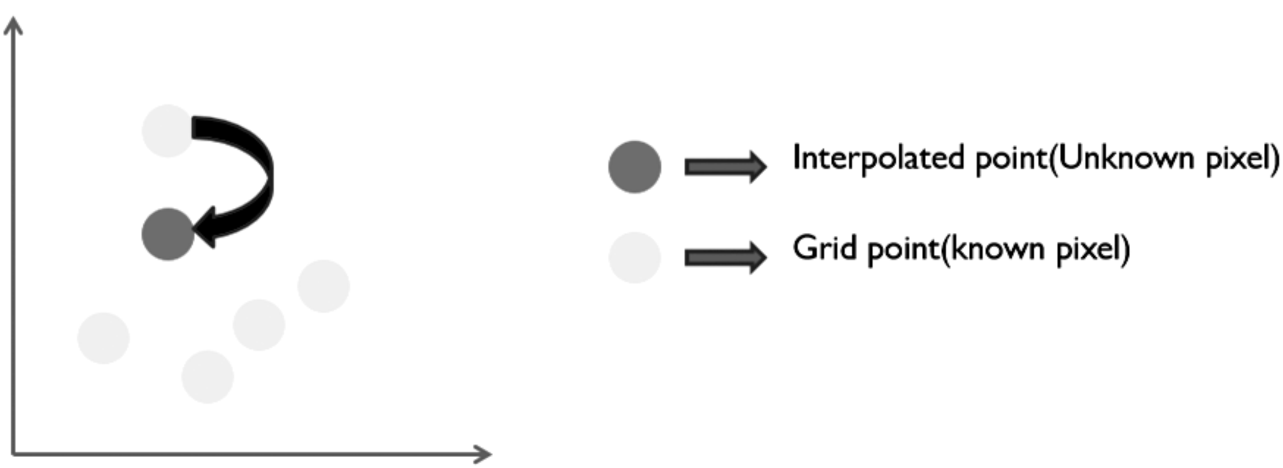

Figure 1:

$$v(x,y)=\begin{cases} f\left(floor\left(\frac{x}{s}\right), floor\left(\frac{y}{s}\right)\right), & rem\left(\frac{x}{s},1\right)\leq 0.5 \text{ and } rem\left(\frac{y}{s},1\right)\leq 0.5 \\ f\left(ceil\left(\frac{x}{s}\right), floor\left(\frac{y}{s}\right)\right), & rem\left(\frac{x}{s},1\right)> 0.5 \text{ and } rem\left(\frac{y}{s},1\right)\leq 0.5 \\ f\left(floor\left(\frac{x}{s}\right), ceil\left(\frac{y}{s}\right)\right), & rem\left(\frac{x}{s},1\right)\leq 0.5 \text{ and } rem\left(\frac{y}{s},1\right)> 0.5 \\ f\left(ceil\left(\frac{x}{s}\right), ceil\left(\frac{y}{s}\right)\right), & rem\left(\frac{x}{s},1\right)> 0.5 \text{ and } rem\left(\frac{y}{s},1\right)> 0.5 \end{cases}$$

Since it does not alter the actual values, it is majorly preferred if suitable variations in the grey level values wants to be retained. Nearest neighbor is the most basic technique and as it requires the least processing time which is major advantage among all the interpolation algorithms because it takes only one pixel into considerationi.e. the nearest one to the interpolated point. This has the results into simply making each pixel larger. Although nearest neighbor method is very efficient because of its time efficiency, the quality of image is comparatively very poor. In this technique due to the fractional part dissertation the visual distortion is occurs which is again an aspect of poor image.

2.2. Bilinear technmique

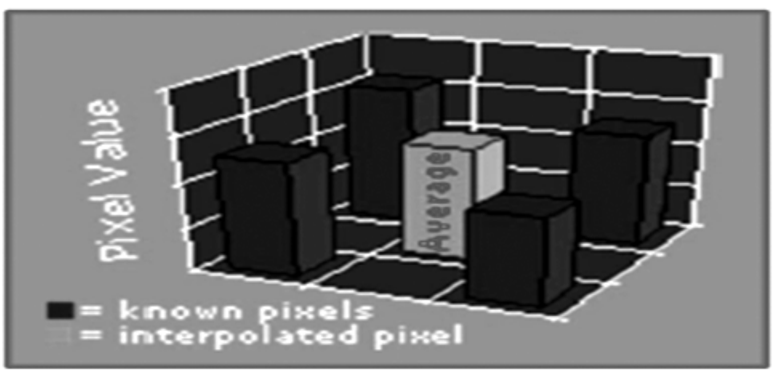

Figure 2:

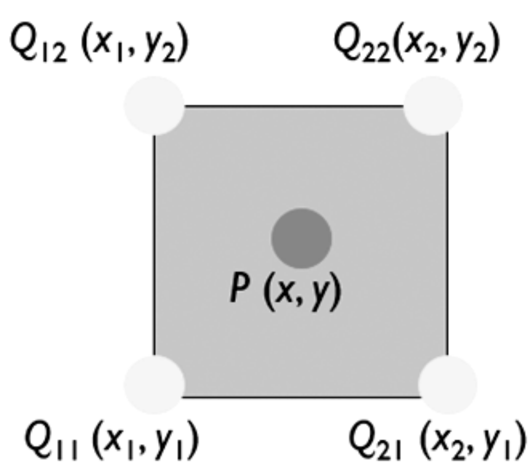

Figure 3:

This is an interpolation technique. It reduces the visual distortion, which is caused by the fractional scaling calculation. This is the bilinear interpolation algorithm technique, in which the fractional part of the pixel address is used to computing a weighted average of pixel brightness values over a small neighborhood of pixels in the source image. Bilinear interpolation produces pseudo resolution or we can say it as artificial that gives a more aesthetically pleasing result, as compare with nearest neighbor.

The gray level of the unknown point is given by:

$$f(x,y) \approx \frac{1}{(x2-x1)(y2-y1)} \begin{matrix} f(Q11)(X2-X)(Y2-Y)+ \\ f(Q21)(X-X1)(Y2-Y)+ \\ f(Q12)(X2-X)(Y-Y1)+ \\ f(Q22)(X-X1)(Y-Y1) \end{matrix}$$

Where f(Q11) , f(Q21) , f(Q12) , f(Q22) are the grey level of the pixel Q11 , Q21 , Q12 , Q22.

In Bilinear interpolation algorithm, it takes into considerationthe closest 2x2 neighborhood from known pixel values surrounding by the unknown pixel and then it takes a weighted average of these four pixels to arrive at its final interpolated value in the resultant image. Theresults obtained by the bilinear interpolation method area much smoother looking images than nearest neighbor.

2.3. Bicubic technmique

The Bicubic interpolation is best results among these three techniques of algorithm as thebicubic interpolated surface is smoother than the respective surfaces obtained by above mentioned methods - bilinear interpolation and nearest-neighbor interpolation. The Bicubic Interpolation is basically obtains the pixel value from the weighted average of the 16 nearest pixels to itsspecified input coordinates, and assigns that values to the output coordinates. For Bicubic Interpolation, the number of grid pixel points needed to evaluate the

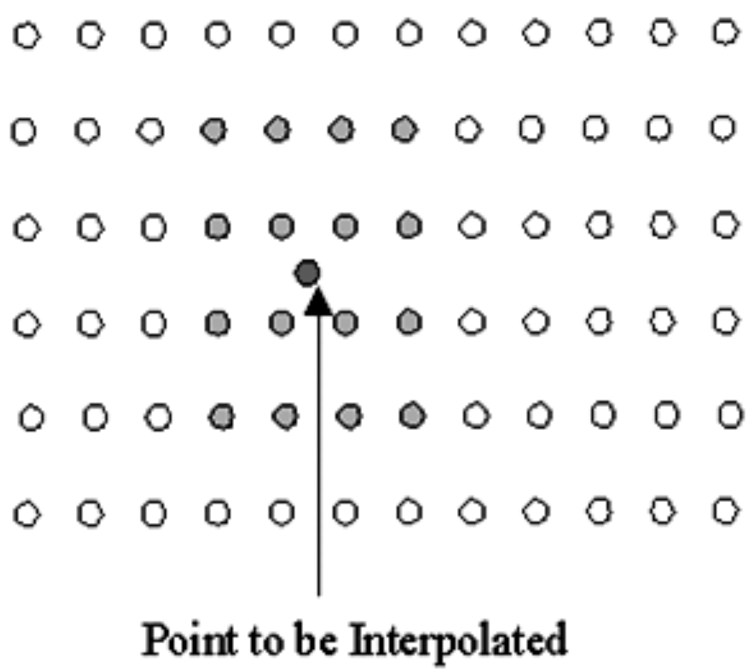

Figure 4:

interpolation function is 16, means two grid points on either side of the point which is under consideration, for both horizontal and vertical directions. Bicubic steps beyond bilinear because it takes into consideration the nearest 4x4 neighborhood of itsknown pixels, which means for a total number of pixels are 16. As these are at various distances from the unknown pixel, nearer pixels are considered as having higher weightage in the process of evaluation.

When using the bicubic interpolation zoomed or scaled image intensity v(x, y) is defined using the weighted sum of mapped 16 neighboring pixels of the original image. As in above method, let the zooming factor is‘s’ and the mapped pixel point in the original image is given by ‘r’ and ‘c’. Then the neighborhood matrix can be defined as,

$$\begin{bmatrix} P11 & P12 & P13 & P14 \\ P21 & P22 & P23 & P24 \\ P31 & P32 & P33 & P34 \\ P41 & P42 & P43 & P44 \end{bmatrix} = \begin{bmatrix} f(r-1,c-1) & f(r-1,c) & f(r-1,c+1) & f(r-1,c+2) \\ f(r,c-1) & f(r,c) & f(r,c+1) & f(r,c+2) \\ f(r+1,c-1) & f(r+1,c) & f(r+1,c+1) & f(r+1,c+2) \\ f(r+2,c-1) & f(r+2,c) & f(r+2,c+1) & f(r+2,c+2) \end{bmatrix}$$

Using the bicubic algorithm,

$$v(x,y) = \sum_{i=0}^{3}\sum_{j=0}^{3} ajj\ pij$$

The coefficients aij can be find using the La-grange equation,

$$a_{ij} = a_i * b_j$$

$$a_i = \prod_{k=0}^{3}, k \neq i \frac{\left(x - ceil\left(s*(c+k)\right)\right)}{ceil\left(s*(c+i)\right) - ceil\left(s*(c+k)\right)}$$

$$b_j = \prod_{k=0}^{3}, k \neq j \frac{\left(y - ceil\left(s*(r+k)\right)\right)}{ceil\left(s*(r+j)\right) - ceil\left(s*(r+k)\right)}$$

When implementing this algorithm I made a mask for defining ai and bj using matrix and then I applied it to the matrix containing the selected 16 points(to reduce the complexity of the algorithm) in order to reduce the processing time.

$$v(x,y) = \begin{bmatrix} a1 & a2 & a3 & a4 \end{bmatrix} * \begin{bmatrix} P11 & P12 & P13 & P14 \\ P21 & P22 & P23 & P24 \\ P31 & P32 & P33 & P34 \\ P41 & P42 & P43 & P44 \end{bmatrix} * \begin{bmatrix} b1 \\ b2 \\ b3 \\ b4 \end{bmatrix}$$

The technique of bicubic interpolation produces comparatively less blurring at the edges. It has lesserother different categories of image distortion than nearest neighbor and bilinear interpolation. On the other side, it’s more computationally demanding technique. Noticeably sharper images areproduced by the Bicubic method in compare with the two methods discussed earlier, and so it’s a classic handling of processing time and output quality. For this reason the bicubic method is used as the standard method in many image editing tools like Adobe Photoshop, printer drivers and in camera interpolation.

3. RESULT

3.1. Original Image

Figure 5:

3.2. Results for Scale 2

Nearest Neighbor

Figure 6:

Bilinear

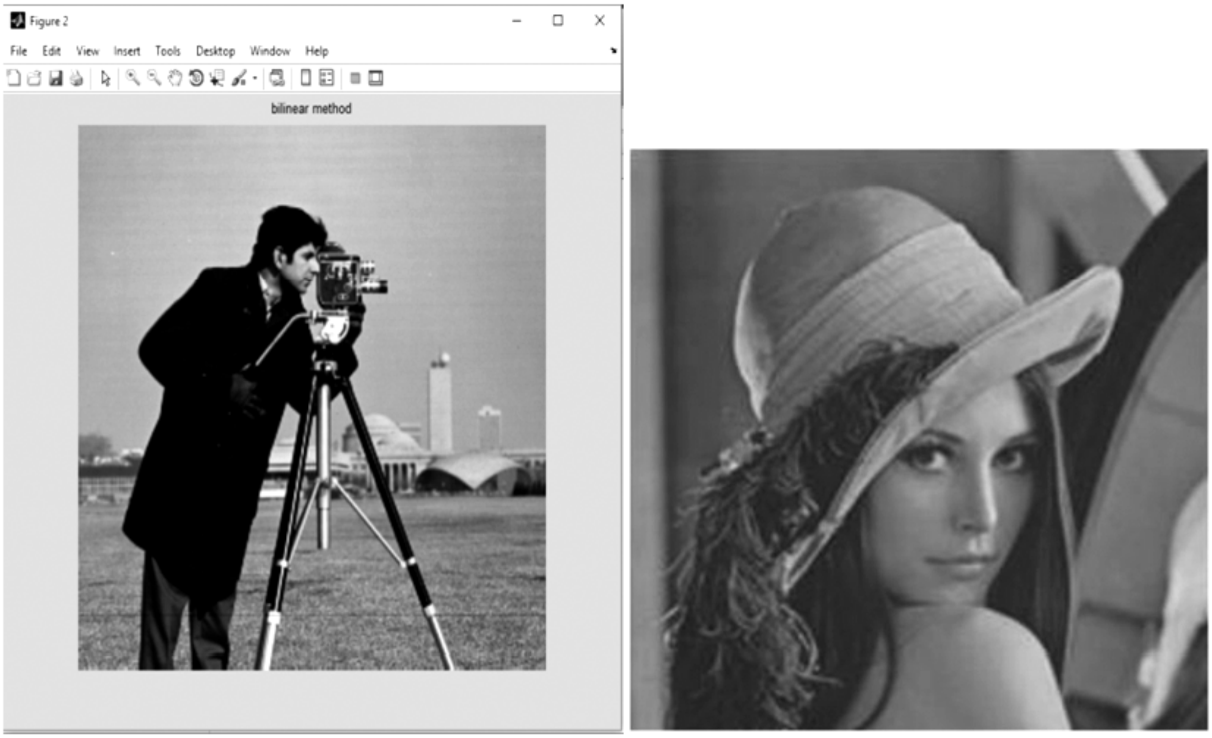

Figure 7:

Bicubic

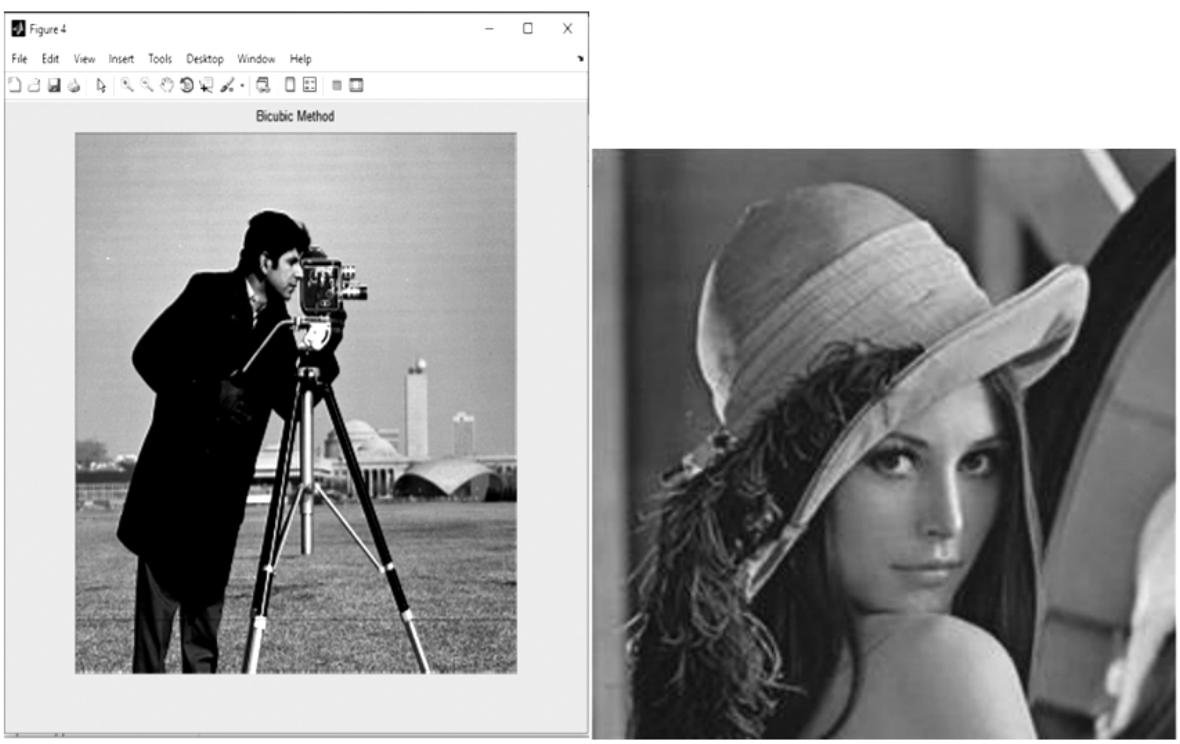

Figure 8:

Table 1
Experiment Result

Scale	*Nearest Neighbor*			*Bilinear Method*			*Bicubic Method*		
	MSE	*PSNR*	*TIME*	*MSE*	*PSNR*	*TIME*	*MSE*	*PSNR*	*TIME*
0.5x	23.2266	34.5049	0.292	23.2266	34.5049	0.446	23.2266	34.5049	0.454
2x	10.5679	37.9249	3.666	11.3767	37.6048	7.832	11.7630	37.4596	5.979
3x	16.66	35.9454	8.036	15.5689	36.3376	17.372	15.2305	36.2422	13.393
4x	14.5242	36.5379	14.590	15.9170	36.1461	30.959	16.9055	35.8845	24.067

Interpolation and original image compare with various interpolations, where bicubic interpolation image peak signal to noise ratio has a better performance than others Table 1 show the mean squared error, peak signal to noise ratio and time performance of my proposed method ofimage.

4. CONCLUSION

There are a number of techniques that can be used to enlarge an image. The three most common were presented here. The implementation of Bicubic Convolution Interpolation gave the best results in terms of image quality; but on the other side it required the greatest amount of processing time. In future as per the application requirement such as in medical science and satellite imaging, using the above method of SR, new methods can be derived by extending or integrating them which can generate more detailed containing SR images as result. This interpolation based approach gives effective result to some extent. However still there are some artifacts and the image is over smooth also.

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