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Futuristic schematic image interpolation

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Abstract— **The field of image processing highly focuses on the enhancement of images in order to remove obscure or any type of commotion in the image. This is required to enhance the quality and nature of the consequent image. This type of enhancement is applied in many areas such as medical diagnosis, remote sensation, horticulture, topography, oceanography etc. Image quality is always affected when it is re-sampled to new co-ordinates because of the errors caused by scaling, quantization and sampling. Digital image processing supports a large number of interpolation techniques that are used for image enhancement. This paper discusses the various interpolation techniques namely: Nearest Neighbor interpolation, Bilinear interpolation, Bi-cubic interpolation. The performance of these techniques is compared by applying these on some well-known benchmark images.**

Index Terms— **enhancement; interpolation; nearest; bilinear; bi-cubic; adaptive; non-adaptive.**

I. INTRODUCTION

In the digital world of imaging, an image is an accumulation of pixels that speak to a physical item or a human. The resolution of a picture is the most imperative territory for image preparing. It speaks to the subtle elements a picture holds. Image processing is the treatment of a picture and it takes information as a picture and creates picture as a yield [14]. This incorporates Picture Upgrade, Picture Division, Picture Pressure, Clamor Evacuation, and so on. Here, image interpolation is a very important mechanism for establishing new points of data not outside a specific domain of a discrete set of familiar points of data [6]. It is the procedure by which a little image is made bigger by expanding the quantity of pixels including the little image. This procedure has been an issue of prime significance in numerous fields because of its wide functionality in satellite symbolism, medical imaging, and especially in military, object evacuation, scratch evacuation, recovering missing territories, image reformation, image zooming and so on. Image zooming produces a large number of artifacts in the original image such as blurriness, zigzag edges, distortion etc. Thus in order to eliminate such artifacts and crocks, image interpolation is used which is as shown in Fig. 1.

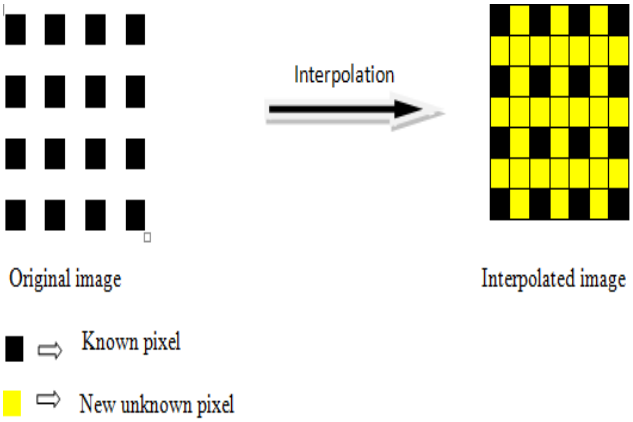

Figure 1. Formation of Interpolated Image

Interpolation can be divided into broad classes: adaptive and non-adaptive.

- Adaptive methods calculate upon what they are interjecting including features like intensity value, edge information, texture, surface etc.;
- Non-adaptive methods are based on direct manipulation of pixels rather than working upon any particular characteristic or content. These methods use similar pattern for all pixels, are easier to implement and treat all pixels identically.

The most commonly used non-adaptive interpolation approaches are: nearest neighbor interpolation, bilinear interpolation, bi-cubic interpolation, spline and other higher order interpolations. Those customary strategies were uniquely distinctive in image resolution, speed, and hypothetical suppositions [10][11][12]. The nearest neighbor assumption does not allow producing a new pixel, rather it sets the value at the blank position by repeating the pixel value positioned at the minimum distance. This results in producing a larger image pixel which in turn produces bulky jagged edges thus making this strategy improper for applications dealing with images of higher resolution. Thus, to avoid this problem, bilinear interpolation was used that induced images with gentle edges but it gave rise to the problem of blurriness of zoomed images. The problem of blurredness was minimized by proposing the methods based on convolution. Such algorithms executed better than the two in terms of the optical aspects but are also irrelevant to use where the pace is of the prime importance [4][5]. Again, in order to alleviate these problems bi-cubic interpolation came into existence that took into account larger number of pixels and needed large amount of time to produce the desired results. Further to deal with other issues, spline interpolation and some higher order interpolation methodologies were developed.

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This paper discusses the working and performance of various interpolation techniques by their application on some images and calculating their PSNR values.

II. Interpolation Techniques

1. Bilinear Interpolation

The major disadvantage of nearest neighbor interpolation is that it cannot be applied to images of higher resolution as it leads to jagged and stair-case type edges which distorts the image quality [1][3]. Thus bilinear interpolation is preferred which takes into consideration the nearest 2 X 2 neighborhood of the known pixel values that surround the unknown pixel. First of all, it is applied row-wise and then afterwards column-wise. An image containing zero elements and of size 2m*2n is then padded with it. Finally, the weighted average of four pixels is computed to reach at its final interpolated value. This results in a much uniform and gentle image as compared to nearest neighbor technique. The steps involved in bilinear interpolation are:

a) First of all, consider an image matrix of size m x n.
b) Decompose it into red, green and blue parts and consider a zero matrix of double its size i.e. 2m x 2n and pad it to the original image.
c) Compute the mean of (i-1)th and (i+1)th rows and put the result in ith row [16].
d) Similarly, compute the mean of (j-1)th and (j+1)th columns and put the result in the jth column.
e) Repeat the procedure for green and blue parts and concatenate the result in the end.

The interpolation kernel is:

$$u(a) = \begin{cases} 0, & |a| > 1 \\ 1 - |a|, & |a| < 1 \end{cases} \quad \ldots(1)$$

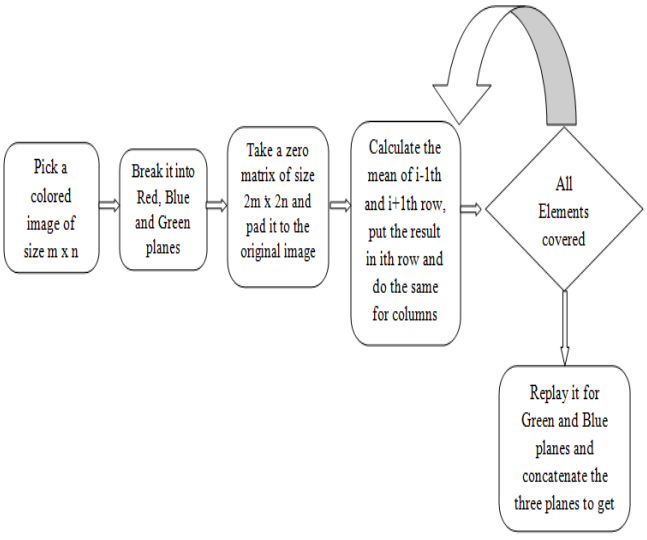


Figure 2. Bilinear Interpolation [13]

2. Bi-cubic Interpolation

Higher order interpolation techniques consider larger number of pixels. If speed is not to be considered, then we use bi-cubic interpolation rather than other techniques. In contrast to bilinear interpolation, bi-cubic interpolation takes into account 16 pixels in the form of a 4 x 4 matrix. The steps followed in this technique are as follows [8][9]:

a) Again consider an image matrix of size m x n and divide it into red, green and blue parts.
b) Consider a zero matrix of double its size i.e. 2m x 2n and pad it to the original image.
c) Consider the nearby 16 pixels, compute their mean and enter the output in ith row and jth column [15].
d) Repeat the procedure for other two parts and concatenate the result in the end.

Images interpolated using this technique are finer and free from blurriness. The bi-cubic kernel is as shown:

$$u(a) = \begin{cases} \frac{3}{2}|a|^3 - \frac{5}{2}|a|^2 + 1, & 0 \le |a| < 11 \\ \frac{-1}{2}|a|^3 + \frac{5}{2}|a|^2 - 4|a| + 2, & 1 \le |a| < 2 \\ 0, & 2 < |a| \end{cases} \quad \ldots(2)$$

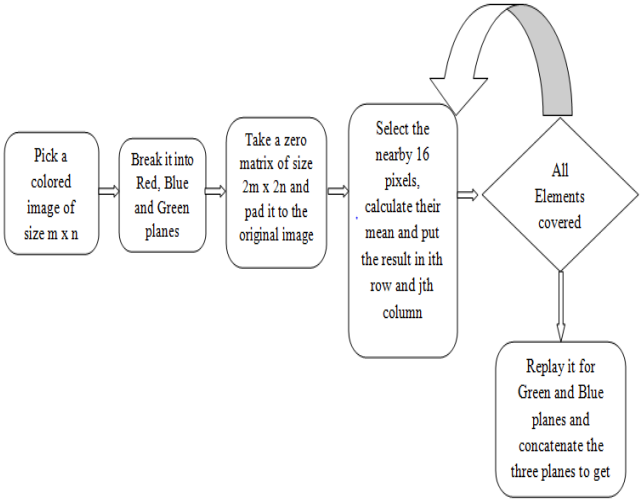


Figure 3. Bi-cubic Interpolation

3. Nearest Neighbor Interpolation

It is the most fundamental strategy and requires the minimum handling time of all the other techniques as it takes into consideration only a single pixel- that is the nearest one to the interpolated bit [2]. It does not involve the overhead of computing the averages or evaluating weights based on complex rules or assumptions. It simply deals with the intensity values of pixels. Image is considered as a matrix consisting of pixel rows and columns. Image enhancement using this technique involves two steps:

a) First of all, a zero valued matrix of double size of the original image is padded to the original image;
b) After that the values of nearest neighbors are allocated to the newly generated pixels as shown in the figure below.

In this technique, each interjected resulting pixel is enrolled the value of the closest sample point in the original image. The kernel of nearest neighbor interpolation is as shown:

$$h(a) = \begin{cases} 0, & |a| > 0 \\ 1, & |a| < 0 \end{cases} \quad \ldots(3)$$

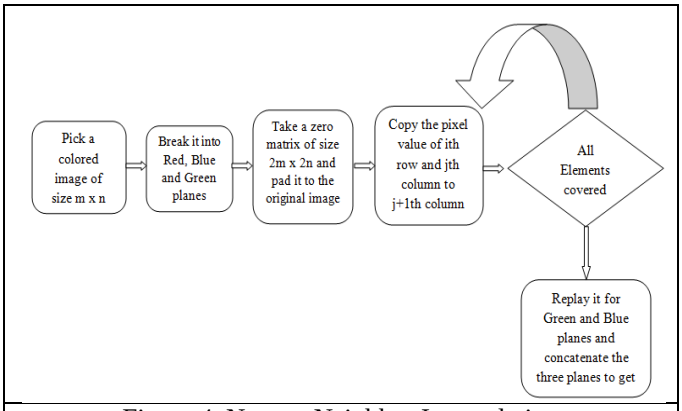
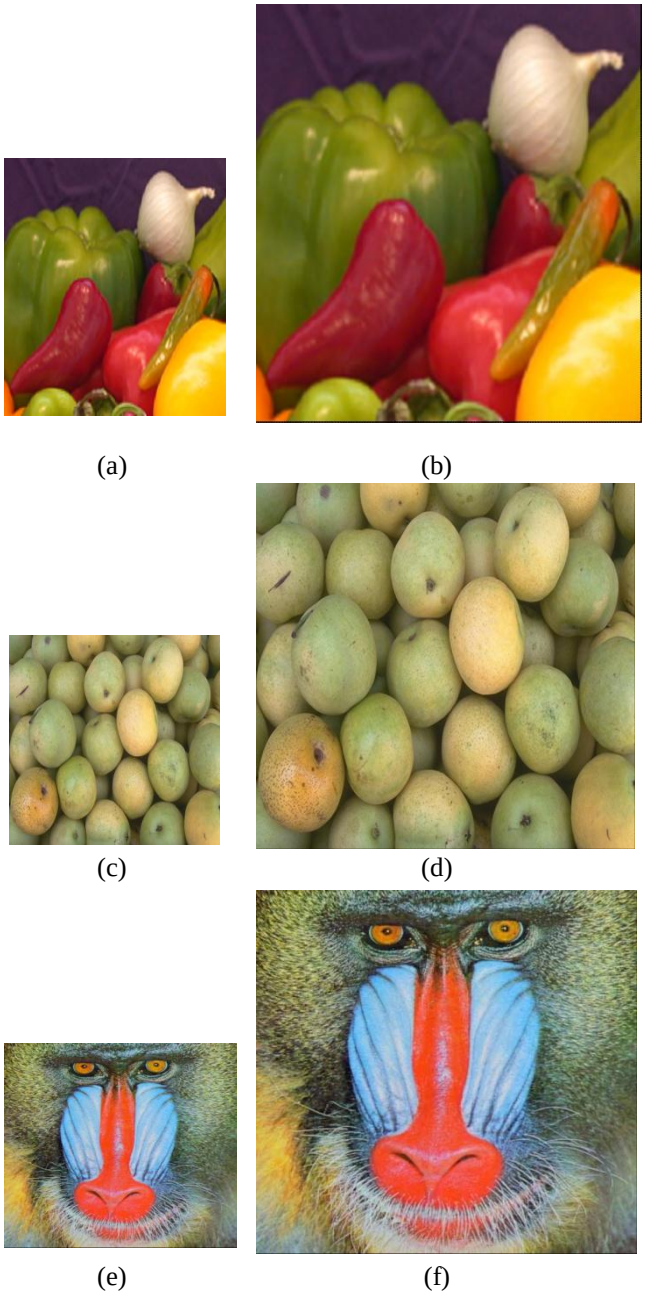


Figure 4. Nearest Neighbor Interpolation

III. Experimental Results



(a) (b)

(c) (d)

(e) (f)

Figure 5. Processing of images: Bilinear interpolation (a) Original Image (b) Zoomed image; Bi-cubic Interpolation (c) Original Image (d) Zoomed image; Nearest Neighbor Interpolation (e) Original Image (f) Zoomed image

IV. Comparison

Technique	Concept	Advantages	Disadvantages
Bilinear	2 X 2 neighborhoods are taken to determine the value of unknown points. The average of four pixels is taken to determine the unknown value.	Better quality of images after zooming, gentle and soothing images is produced.	Not suitable for applications where edges are to be considered as it may cause blurred edges.
Bi-cubic	4 x 4 neighborhoods are taken to determine the value of interpolated point. Average of 16 pixels is calculated after assigning higher weights to closest pixels than the farther ones.	Sharp and stinging images are produced making an ideal combination of processing time and quality.	Ringing artifacts may be introduced on edges as weighted average method is used.
Nearest Neighbor	It deals with the pixel at the least distance to the interpolated point. A single pixel is taken to determine the value of unknown point.	Processing time is the least making it a high speed technique as only one pixel is used [7].	Not suitable for very high resolution images as it may degrade the quality resulting in jagged images.

V. CONCLUSION

This paper has analyzed the performance of various interpolation techniques used for image enhancement. These techniques have been tested on well-known benchmark images and the results conclude that Bi-cubic interpolation is the most prominent among the others as it makes an absolute combination of processing speed and image quality. Nearest neighbor and bilinear interpolation methods may cause jagged edges thus highly affecting the image quality. Our experimental results show that bi-cubic interpolation outperforms other two interpolation techniques.

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