

Comparative Analysis of Interpolation and Texture Synthesis Method for Enhancing Image

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Abstract: Interpolation is the method of enlarging or stretching an image from a smaller original image to a larger resultant image. Whereas, Texture synthesis is the method of cleaning the image by using patches or pixels for making the image resolution higher and better than the original image. Here in this paper we have given an overview of different Interpolation and Texture Synthesis Methods. We have reviewed various Interpolation Algorithms for enlarging the image. Also, we have reviewed different Texture Synthesis methods for making the image resolution better and finer.

Keywords: Interpolation, Texture Synthesis, Image Enhancement, DWT.

I. INTRODUCTION

An image Interpolation is the method of enlarging the smaller low resolution image to a larger high resolution image which can be defined as Image Scaling. Whereas, approximating the value of continues function by using discrete samples is also defined as an Interpolation [16]. Nowadays, Image interpolation is also available in many image processing tools like Photoshop [1]. Also it has many applications like digital photograph, remote sensing, medical imaging, image decomposition, to correct spatial distortion and many more. We have shown the basic concept of image enlargement using Interpolation in figure 1.

The digital image is a signal which mainly varies in two dimensions. This signal is sampled and quantized to get values. All these values are called the pixels of an image. While increasing the resolution of an image from low to high, it is called up-sampling or up-scaling whereas, the reverse is called down sampling or down scaling [22]. Here, in this paper we have mainly focused on up-sampling only. Primarily, there are two main categories for interpolation: Adaptive and Non-Adaptive. We have shown the comparisons of both the categories.

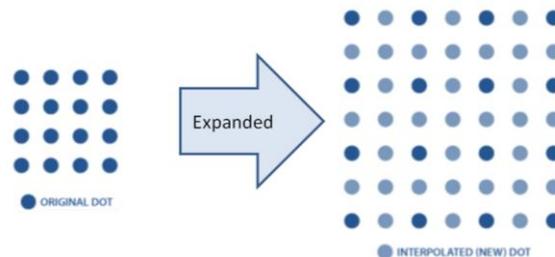


Figure 1. Scaling of an Image using basic Interpolation concept.

The process of constructing a large digital image from a small digital sample image algorithmically is known as Texture Synthesis. Basically, Texture synthesis is used to create large non-repetitive background images and expand small pictures by removing noise and also to fill in holes in images. The Primary goal of a Texture Synthesis process is to synthesize a new texture in such a way that when it is been perceived by some human observer, it appears to be generated by same underlying process.

Basically, two methods are used for cleaning gray scale images: Pixel Based Texture Synthesis and Patch Based Texture Synthesis. Whereas Segmentation (object select by boundary) and selecting area (select image area) are used for cleaning the Color images (RGB image) [20]. Also, noise can be removed by taking different size and shapes of patch and then using both methods. Peak Signal to Noise Ratio (PSNR) is used as a measure of quality.

We have organized our paper in a following manner. Section II gives an overview of Image Interpolation using Adaptive and Non-Adaptive method. Section III describes the method for Enhancing and cleaning the image using Texture Synthesis Method. Section IV shows the comparison for the methods of Interpolation and Texture Synthesis. Section V concludes the paper.

II. INTERPOLATION

Interpolation is the process of transferring image from one resolution to another without losing image quality. In Image processing field, image interpolation is very important function for doing zooming, enhancement of image, resizing any many more. Here we have categorized Interpolation into two: Non-Adaptive Interpolation and Adaptive Interpolation.

A. Non-Adaptive Interpolation

- *Nearest Neighbour Interpolation:* This method uses nearest neighbour’s pixel to fill interpolated points and so it is considered to be very simple and requires less computation. In this method the available values are just copied, not the interpolated values as it do not change the values.
- *Bilinear Interpolation:* The interpolated point is filled with four closest pixel’s weighted average in this method. Here in this method we perform two linear interpolations, in horizontal direction and then linear interpolation in vertical direction. In Bilinear Interpolation method we calculate four interpolation functions for grid point.
- *Bicubic Interpolation:* The interpolated point is filled with sixteen closest pixel’s weighted average in Bicubic Interpolation. Because of these, we get a sharper image than Bilinear Image. The comparison between the three Non-Adaptive Interpolation methods is shown below in figure 2.

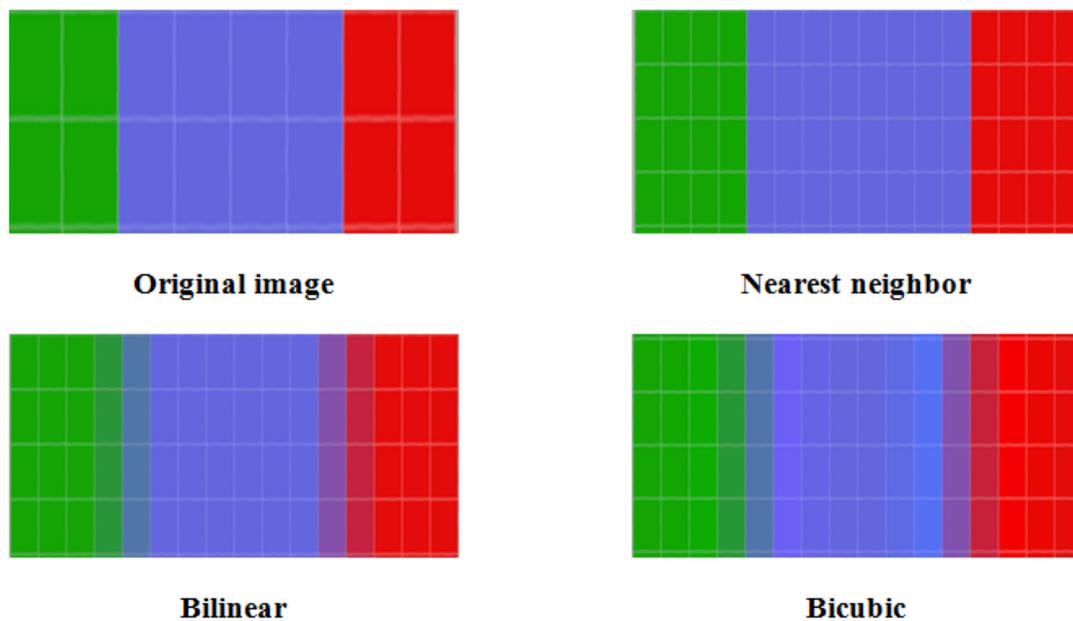


Figure 2. Comparison between Bilinear, Bicubic and Nearest neighbor.

B. Adaptive Interpolation

- *Threshold Based Interpolation:* In this method, more pixel values are considered while calculating interpolated point’s value as well as the noise present in image. Here instead of finding mean value of pixels, we can use max or median function of matlab as per the type of image [11]. Example is shown in figure 3.

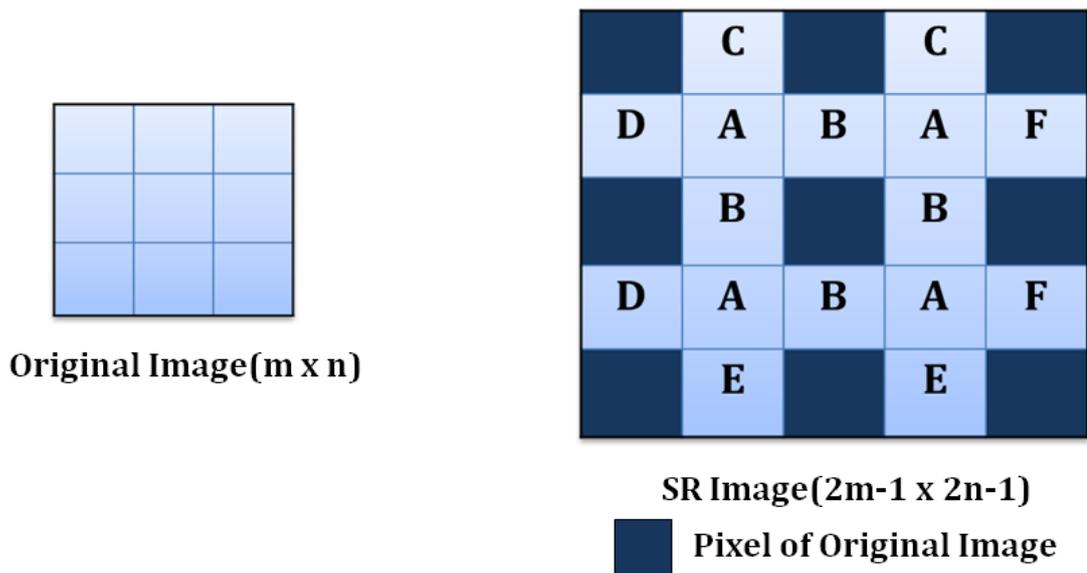


Figure 3. Threshold Based Interpolation

- *Edge Guided Interpolation:* In an Edge-Guided Image Interpolation method we used Directional Filtering and Data Fusion presented in [5]. Here we partition pixels into two directional and orthogonal subsets for the edge information. Directional interpolation is made for each Subset and two interpolated values are fused. The algorithm presented till now works for gray scale images only. Here we have presented the algorithm that works for RGB image also. Each R, G and B components of one image are stored into three different images of two dimensions and give that as a input to original algorithm. Finally all the three output arrays are merged into single RGB image [4].

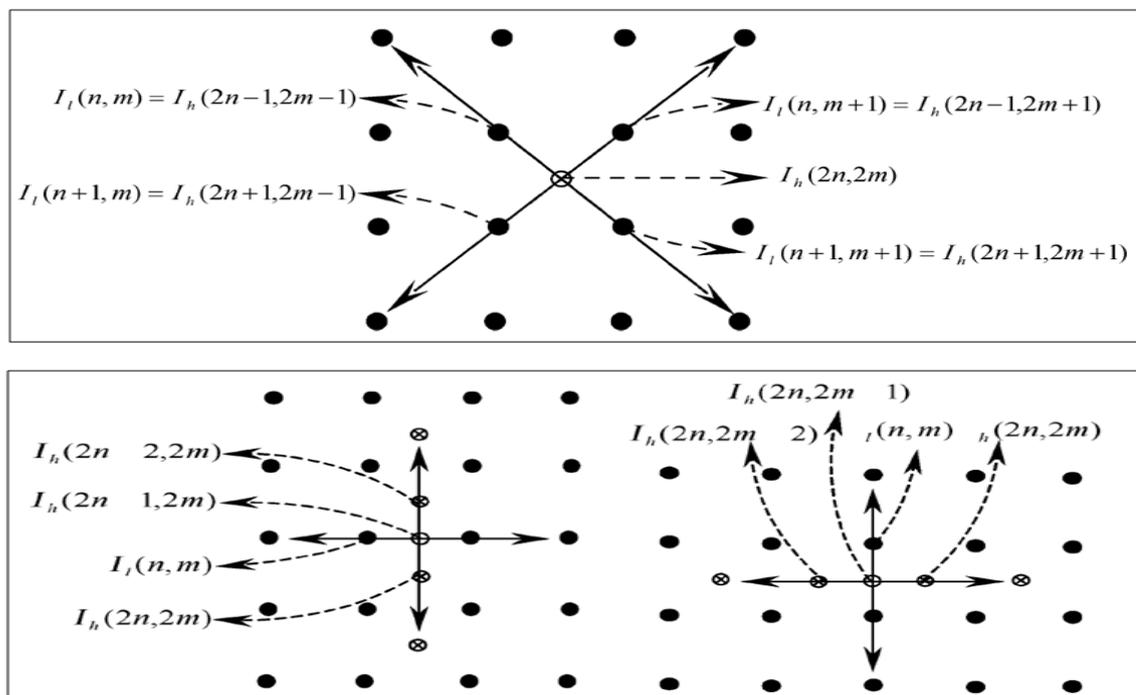


Figure 4. Edge Guided Interpolation

- *DWT Based Interpolation:* We have studied “image up-sampling using DWT presented in [9]. Here they have used 9/7 bi-orthogonal spline based DWT. The Presented figure shown below preserves the edges and colour of original image. Below we have shown the figure 5, how the image up-sampling is done where S is scaling factor and I is original image [22].

$I * S$				HL(0,0)	0	HL(0,1)	0
				0	0	0	0
				HL(1,0)	0	HL(1,1)	0
				0	0	0	0
LH(0,0)	0	LH(0,1)	0	0			
0	0	0	0				
LH(1,0)	0	LH(1,1)	0				
0	0	0	0				

Figure 5. DWT Based Sampling.

III. TEXTURE SYNTHESIS

Mapping of an image onto the object surface either synthetic or digitized, then such a technique is called texture mapping [17] [18]. The mapped image, usually rectangular, is called a texture map or texture [4]. A texture can be used to modulate various surface properties, including color, reflection, transparency, or displacements. In the field of computer graphics the content of a texture can be very general in mapping a color texture patterns. Texture can be referred as visual or tactile surfaces composed of repeating patterns, such as a fabric.

Texture synthesis is the process of algorithmically constructing a large digital image from a small digital sample image by taking advantage of its structural content. Texture synthesis can be used to fill holes in images, create large non-repetitive background images and expand small pictures [17]. Here we have categorized the method of Texture Synthesis into two: Pixel Based Texture Synthesis and Patch Based Texture Synthesis.

A. Pixel Based Texture Synthesis

Pixel-based texture synthesis method is based on a non-parametric sampling method. It also assumes that a pixel value at a certain location only depends on its immediate neighbourhood [19]. When choosing the value of the next pixel in the output image the method uses the populated portion of the pixels neighbourhood to exhaustively search for the best matched region in the sample image [21].

B. Patch Based Texture Synthesis

The method synthesizes a new image by stitching together small patches from the sample image. In this method synthesizes a resultant image is generated block by block in raster order. Square blocks are used to capture the primary pattern in the sample texture. A block is randomly selected from the sample image and pasted into the new image beginning at the first row and the first column. Then another block is selected as a candidate neighbour. It is placed next to the first block so that they overlap one another [21].

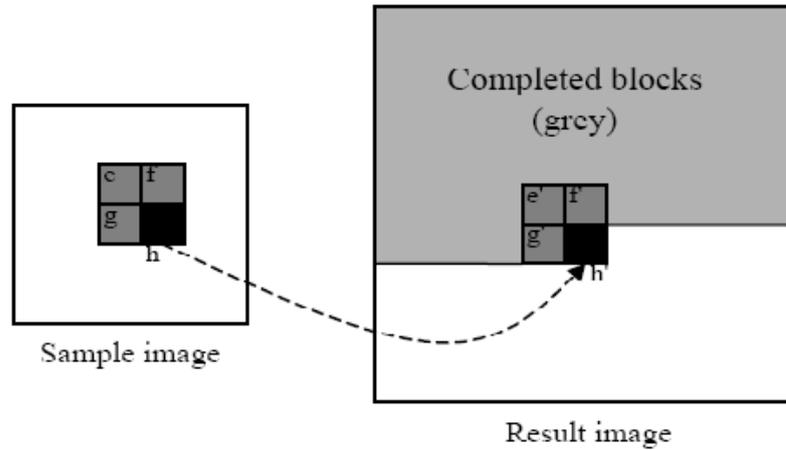


Figure 6. Pixel in Patch

IV. COMPARISON

We have used matlab for showing the comparison between different Interpolation methods. Experiments have been done on LINA images of the size 256 x 256. We have used Pick Signal to Noise Ratio (PSNR) for comparison of all algorithms. Visual quality is the most important parameter for the effectiveness. We have shown all the comparisons in the below table 1. The PSNR is defined as: $PSNR = 20 \cdot \log_{10}(MAX_i / \sqrt{MSE})$.



Figure 7. Original Input Image



Figure 8. a. nearest neighbour, b. Bilinear, c. Bicubic, d. Edge Guided, e. DWT based, f. Threshold based

Table 1. Comparison of different interpolation methods

	<i>PSNR(dB) LENA Image</i>
<i>Nearest neighbour</i>	26.05
<i>Bilinear</i>	27.12
<i>Bicubic</i>	27.18
<i>Edge Guided</i>	30.43
<i>DWT based</i>	28.81
<i>Threshold based</i>	29.99

V. CONCLUSION

In this paper we have shown the comparative analysis of different interpolation and texture synthesis methods. We have also shown the comparison of different Interpolation methods. For various purposes adaptive methods are better and for generalized tools, non-adaptive methods are good. For image up sampling interpolation method is very good. In future we would like to modify above methods so as to make it work better.

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