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A Review on Different Image Interpolation Techniques for Image Enhancement

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***Abstract*— Image enhancement is an important processing task in image processing field. By applying image enhancement, blur or any type of noise in the image can be removed so that the resultant image quality is better. Image enhancement is used in various fields like medical diagnosis, remote sensing, agriculture, geology, oceanography. There are numbers of techniques for image enhancement. Image interpolation is used to do enhancement of any image. This paper gives overview about different interpolation techniques like nearest neighbor, bilinear, bicubic, new edge-directed interpolation (NEDI), data dependent triangulation (DDT), and iterative curvature-based interpolation (ICBI).**

***Keywords* — Non-adaptive techniques, adaptive techniques, interpolation.**

I. INTRODUCTION

Interpolation is a technique in which we estimate approximate continues value of a function. Many of the interpolation techniques like nearest neighbor, bicubic, bilinear are available in many image tools like Photoshop. Various applications of interpolation are image resizing, image zooming, image enhancement, image reduction, sub pixel image registration, image decomposition and to correct spatial distortions and many more [3]. In figure I we have shown the basic concept of how we can enlarge image using interpolation. Image interpolation is the process of transferring image from one resolution to another without losing image quality [3].

Below figure shows the effect of interpolation on an image [3].

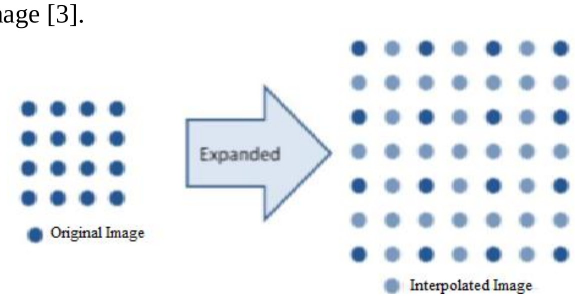

Fig I: Effect of interpolation [3]

Interpolation techniques are mainly divided in two categories:

1. Non-adaptive techniques
2. Adaptive techniques

II. NON-ADAPTIVE TECHNIQUES

Non-adaptive interpolation techniques are based on direct manipulation on pixels instead of considering any feature or content of an image. These techniques follow the same pattern for all pixels and are easy to perform and have less calculation cost. Various non-adaptive techniques are nearest neighbor, bilinear and bicubic.

A. Nearest Neighbor interpolation

It is the most basic interpolation technique and requires less processing time among all the interpolation techniques. In this technique the interpolated pixel is replaced by the nearest pixel. Nearest neighbor interpolation is a simple method of linear interpolation. It is easy to implement. It gives good result when the image has high resolution pixels. In this some information at the edges is lost.

The interpolation kernel for nearest neighbor interpolation is [3]:

$$u(x) = \begin{cases} 0 & |x| > 0.5 \\ 1 & |x| < 0.5 \end{cases}$$

Where x = distance between interpolated point and grid point.

B. Bilinear interpolation

Bilinear interpolation takes a weighted average of the 4 neighborhood pixels to calculate its final interpolated value. The result is much smoother image than the original image. When all known pixel distances are equal, then the interpolated value is simply their sum divided by four [3]. This technique performs interpolation in both directions, horizontal and vertical. This technique is give better result than nearest neighbor interpolation and take less computation time compare to bicubic interpolation.

The interpolation kernel for bilinear interpolation is [3] :

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u(x) = { 0 |x| > 1
{1 – |x| |x| < 1

Where x = distance between interpolated point and grid point.

C. Bicubic interpolation

Bicubic interpolation is best among all non-adaptive techniques. Bicubic interpolation takes a weighted average of the 16 pixels to calculate its final interpolated value. These pixels are at various distances from the unknown pixel. Closer pixels are given a higher weighting in the calculation [3]. Bicubic gives sharper images than previous two methods. This technique gives better result but take more computational time. When time is not a constraint then this technique give the best result among all the non-adaptive techniques.

The interpolation kernel for bicubic interpolation is [3]:

{3/2|x|3 – 5/2|x|2 + 1 0<=|x| < 1
u(x) = {-1/2|x|3 + 5/2|x|2 – 4|x| + 2 1<= |x|<2
{0 2 < |x|

Where x = distance between interpolated point and grid point.

III. Adaptive Techniques

Adaptive techniques consider image feature like intensity value, edge information, texture etc. Non-adaptive interpolation techniques have problems of blurring edges or artifacts around edges and its only store the low frequency components of original image. For better visual quality image must have to preserve high frequency components and this task can be possible with adaptive interpolation techniques. These techniques give better result than non-adaptive techniques but take more computational time. Various adaptive techniques are NEDI, DDT, ICBI and many more.

A. New Edge-Directed Interpolation

NEDI technique is a combined approach of bilinear interpolation and covariance based adaptive interpolation. In linear interpolation techniques have blurred edges and artifacts. Mainly two purposes to introduce NEDI technique: first is to produce better visual quality then linear interpolation techniques (Bilinear and Bicubic) and second is to reduce the computational complexity of covariance based adaptive interpolation technique.

Without the loss of generality, we assume that the low-resolution image $X_{i,j}$ of size H*W directly comes from of size of 2H*2W, i.e.,$Y_{2i,2j}=X_{i,j}$ [14] .Following steps are involved in NEDI technique:

Step 1: Calculate the linear interpolation coefficients according to classical Wiener filtering theory and the coefficients given by,

$$\vec{\alpha} = R^{-1}\vec{r}$$

Where, R and r is the local covariance at the high resolution. In this

$$\hat{R} = \frac{1}{M^2}C^T C$$

$$\hat{\vec{r}} = \frac{1}{M^2}C^T \vec{y}$$

Where, $\vec{y} = [y_1 \ldots y_k \ldots y_{M^2}]^T$ is the data vector containing the M*M pixels inside the local window and C is $4*M^2$ is a data matrix whose k^{th} column vector is the four nearest neighbors of y_k along the diagonal direction [14].

Step 2: Calculate the high resolution covariance from low resolution image,

$$\vec{\alpha} = (C^T C)^{-1}(C^T \vec{y}).$$

Step 3: Put the value of α of above equation into below equation and get the resultant interpolated image,

$$\hat{Y}_{2i+1,2j+1} = \sum_{k=0}^{1}\sum_{l=0}^{1} \alpha_{2k+l} Y_{2(i+k),2(j+l)}$$

The above equation is core part of this technique [14]. Only edge pixels are interpolated by these steps in order to reduce the computational complexity and bilinear interpolation technique is used for non-edge pixels.

B. Data Dependent Triangulation

Data dependent triangulation interpolation technique is developed to improve the visual quality of image and to reduce the computational complexity of image with respect to other linear interpolation techniques. DDT is mainly used to overcome the disadvantages of bilinear interpolation technique.

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DDT gives better result than bilinear interpolation in term of visual appearance and has low computational complexity.DDT is better than other interpolation technique like NEDI, Edge Guided interpolation for these following reasons:

1. DDT is as simple as bilinear interpolation technique while the other techniques are complex.
2. DDT can be used in arbitrary enhancement, arbitrary scaling while other techniques are defined for magnifying [9].

In DDT first we have to find the triangles from four neighboring pixels. The diagonal pixels divide the four pixels into two triangles. Direction of diagonal is based on the edge present in the image [9]. After that we have to decide which triangle is best for our new pixels (consider one edge so it consist two pixels) .If the new pixels lie in the same triangle than apply interpolation based on only that three triangle vertices. If the new pixels are not lies in the same triangle then, we first store the edge direction of the four pixels in lookup table. Do inverse mapping for each of new pixels and decide remaining pixels for those new pixels. Use that table in which edge direction information is store to decide appropriate triangle and apply bilinear interpolation on that triangle to get interpolated image.

In general, steps for DDT are as follows [16]:

Step 1: For each set of four low resolution pixels, calculate edge as diving pixels into two triangles

Step 2: Create an image mesh which store the direction of each edge

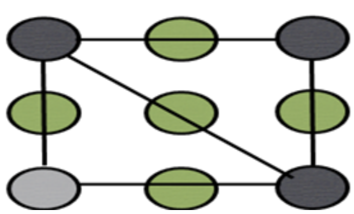

Fig II: Image mesh [16]

Step 3: Use linear interpolation within triangles

C. Iterative Curvature-based Interpolation

Iterative curvature-based interpolation technique focuses on estimation of direction and based on second order derivatives.

Main purpose of introducing ICBI technique to minimize the artifacts presented in image compare to other technique like NEDI and other linear and non-linear interpolation techniques.

ICBI technique has lower computational cost then other non-adaptive techniques. ICBI technique is a combination of two techniques. In first technique, the new pixels are computed by interpolating along the direction (FCBI, Fast Curvature Based Interpolation). In second technique, we modified the interpolated pixels using iterative method with energy term for edge preservation purpose [2].

First technique, FCBI is same the Data Dependent Triangulation interpolation technique, but instead of taking the average value of two opposite neighbor pixels, we consider second order derivatives in two diagonal direction and compute new pixel values in such a direction where the estimated derivative is low.

In second technique, the energy term is sum of the curvature continuity, curvature enhancement and iso-levels curves .First we compute, for each new pixel, the energy function U(2i+1; 2j+1) and the two modified energies $U^+(2i+1;2j+1)$ and $U^-(2i+1;2j+1)$, i.e. the energy values obtained by adding or subtracting a fixed value called threshold value to the local pixel value $I(2i+1;2j+1)$ [2] and assign this intensity value to pixel. This procedure is iteratively repeated until the sum of the modified pixels at the current iteration is lower than a fixed threshold value.

Overall procedure for ICBI technique is as follows [2]:

Step 1: Put original pixels in the enlarged grid at locations 2i,2j

Step 2: Insert pixels at locations 2i+1,2j+1 with the FCBI method

Step 3: Apply iterative correction until the image variation is above a given threshold

Step 4: Insert pixels in the remaining locations with the FCBI method

Step 5: Apply iterative correction to the added pixels

Step 6: Repeat the whole procedure on the new image for further enlargements

IV. Comparision Of Interpolation Algorithms

All below figures show the comparison of all algorithm described above in this paper.

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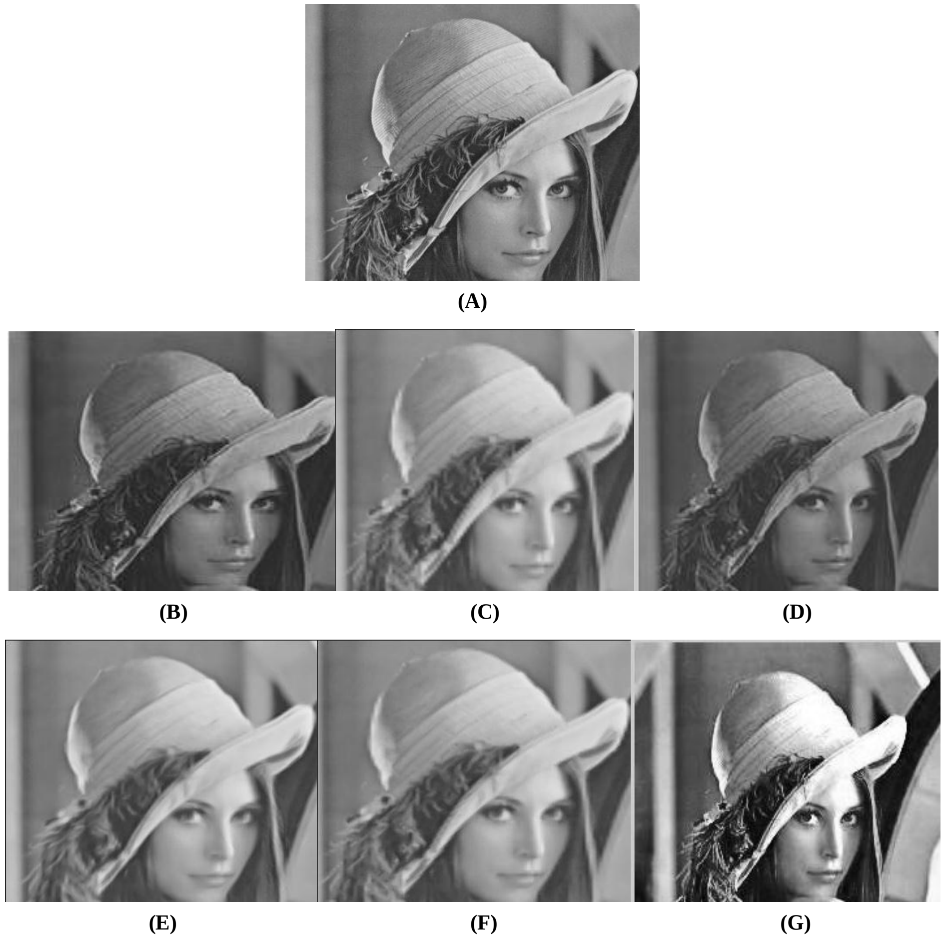

Fig III: Comparison of images. (A) Original image, (B) Nearest neighbor, (C) Bilinear, (D) Bicubic, (E) NEDI, (F) DDT, (G) ICBI. [16][3][2]

The below table shows the comparison of all images with respect to its PSNR ratio (in dB):

Table I
Analysis table with respect to PSNR ratio [16][3][2]

Interpolation techniques	PSNR (in dB)
Nearest neighbor	26.05
Bilinear	27.12
Bicubic	27.18
NEDI	37.37
DDT	37.42
ICBI	40.99

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V. Conclusion And Future Work

In this paper we have study different image interpolation techniques like non-adaptive and adaptive techniques.

We also study that adaptive techniques are better in terms of visual appearance of image but it take more computational time. When time is not an obstacle then we choose the adaptive technique otherwise non-adaptive techniques are preferable. Based on our application we used either of these interpolation techniques.

In future, we will try to combine these adaptive and non-adaptive techniques to overcome their individual's disadvantages and make the resulting image better in terms of visual appearance and in terms of computational time.

References

[1] Ammu Anna Mathew, S. K. (April 2013). Brightness and Resolution Enhancement of Satellite Images using SVD and DWT. International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue4, 7.

[2] Andrea Giachetti, N. A. (2008). Fast Artifacts-Free Image Interpolation. BMVC , 10.

[3] Ankit Prajapati, S. N. (November 2012). Evaluation of Different Image Interpolation Algorithms. International Journal of Computer Applications, 7.

[4] Asuni, A. G. (2010). Real time artifact-free image upscaling. IEEE TRANSACTIONS ON IMAGE PROCESSING 1, 9.

[5] Bagawade Ramdas P., B. K. (April 2012). wavelet transform techniques for image enhancement survey. International Journal of Emerging Technology and Advanced Engineering, 6.

[6] Bandi Mahesh, E. K. (Sep - Oct 2013). A Novel Method For Image Enhancement By Using SWT And DWT. International Journal of Computer Science Trends & Technology - Volume1 Issue2, 4.

[7] Battula.R.V.S.Narayana. (2012). Image Resolution Enhancement by Using Stationary and Discrete Wavelet Decomposition. I.J. Image, Graphics and Signal Processing, 6.

[8] Bo Wang, D. Z. (2007). Improved Fast Color Image Edge-Directed Interpolation With Statistical Feature. The International Exchange Program of Harbin Engineering University, 4.

[9] Dan Su, P. W. (10/2002). Image Interpolation by Pixel Level Data-Dependent Triangulation. COMPUTER GRAPHICS Forum, 8.

[10] Demirel, G. A. (June 2010). Image Super Resolution Based on Interpolation of Wavelet Domain High Frequency Subbands and the Spatial Domain Input Image. ETRI Journal, 5.

[11] Lei Zhang, W. ,. (2009). Two-stage image denoising by principal component analysis with local. Elsevier, 19.

[12] Lei Zhang, X. W. (AUGUST 2006). An Edge-Guided Image Interpolation Algorithm via Directional Filtering and Data Fusion. IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 15, NO. 8.

[13] Mrs.S.Sangeetha#1, M. H. (July 2013). Image Resolution Enhancement Technique Based on the Interpolation of the High Frequency Subbands Obtained by DWT. International Journal of Engineering Trends and Technology (IJETT), 7.

[14] Xin Li, M. T. (OCTOBER 2001). New Edge-Directed Interpolation. IEEE TRANSACTIONS ON IMAGE PROCESSING, 7.

[15] Performance Evaluation of Edge-Directed Interpolation Methods for Images

[16] Edge Directed interpolation overview.PPT, Nickolas Mueller, Yue lu, and Minh N.Do