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An Analysis on Different Image Interpolation Techniques for Image Enhancement

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ABSTRACT: Image enhancement is the process of highlighting certain information of an image in image processing field. Image enhancement can be used to remove any type of noise or blur in the image by which the resultant image quality is better. Image enhancement is applicable on mask mode radiography, remote sensing, forestry, hydrology, and human interpretation. There are various techniques for image enhancement. Image interpolation can occur in all digital images at some stage or in image enlargement. It can be used to do enhancement of images. This paper presents an overview about various interpolation techniques like Nearest Neighbor, Bilinear, Bicubic, Data Dependent Triangulation (DDT) and Iterative Curvature-Based Interpolation (ICBI).

KEYWORDS: Interpolation: Non-adaptive techniques and adaptive techniques.

I. INTRODUCTION

Interpolation is a method of fitting the data points to represent the value of a function in which related known values are applied to estimate an unknown values or potential yield of a security. By using other established values it can be obtained that they are located in sequence with the unknown value. We can also estimate approximate continuous value of a function. The interpolation techniques like nearest neighbor, bicubic, bilinear are present in many image tools.

In Interpolation method, we get the discrete data set to derive a function where that function passes through the given data points. It helps to estimate the data points in between the given data ones. This method is mainly used to calculate the value of a function for an intermediate value of the independent function. Interpolation is a method of collecting the unknown values that lie in between the known values. It is mainly used to find the unknown values for any geographical related data points such as rainfall, noise level, elevation, and so on. Without losing the image quality [3] image is transferred from one resolution to another resolution the below following figure I represent the interpolation effect on an image [3].

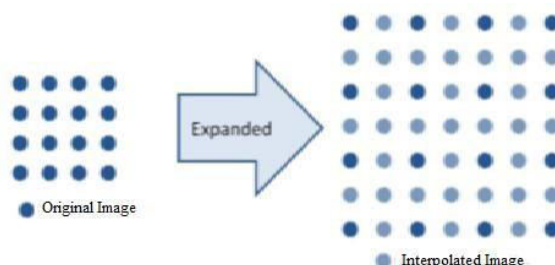


Fig I: Effect of interpolation [3]

Interpolation techniques are classified in two types as follows:

1. Non-adaptive techniques
2. Adaptive techniques

II .NON-ADAPTIVE TECHNIQUES

Non-adaptive interpolation techniques are based on direct manipulation on pixels depending on their complexity, this use anywhere from 0 to 256 (or more) adjacent pixels when interpolating. we receive the most accurate value by adding the more adjacent .The more adjacent pixels added is what but it comes at the expense of longer processing time.

It's also applied for fixed pattern to each pixel without considering its other parameter as features, edges of images. Same pattern for all the pixels is followed in these techniques which is easy to perform and have less calculation cost. Various non-adaptive techniques are nearest neighbor, bilinear, bicubic and filtering-based (Re-sampling) techniques.

A. Nearest Neighbor interpolation

The nearest-neighbor interpolation technique both image resizing operations are performed by selecting the value of the nearest adjacent element .This interpolation is also known as proximal interpolation. It is widely used in real-time 3D rendering to select color values for a textured surface. The algorithm is very simple and requires less processing time and gives good result

The nearest neighbor interpolation as follows [3]:

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

Where X is defined as the distance between interpolation point and grid point

B. Bilinear interpolation

The bilinear interpolation method can be arrived by using linear interpolation. It begins from one direction, and then it ends in other direction. A new pixel value is obtained to the distance weighted average of the four nearest pixel values. It leaves much to be desired in image quality that is especially noticeable at the edges in images. The interpolated value is simply their sum divided by four [3] when all known pixel distances are equal, then this technique performs interpolation in both horizontal and vertical directions. When compared to nearest neighbor interpolation this technique is give better result and take less computation time compare to bicubic interpolation.

The bilinear interpolation as follows [3] :

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

Where X is defined as the distance between interpolation point and grid point.

C. Bicubic interpolation

The Bicubic interpolation is the done by processing bilinear interpolation or by using the nearest neighbor in image resembling, when speed is not an issue, because it provides a less interpolation distortion. It is the best among all non-adaptive techniques. It takes a weighted average of the 16 pixels to calculate its final interpolated value. These pixels present there are measured at various distances from the unknown pixel. The higher weighting in the calculation [3] is given to Closer pixels. It gives sharper images than previous two methods. This technique produces us the better result but it takes more computational time. When time is not a constraint then this technique presents us the best result when comparing to all the non- adaptive techniques.

The bicubic interpolation as follows [3]:

$$\{ 3/2|x|^3 - 5/2|x|^2 + 1$$

$$0 \leq |x| < 1$$

$$u(x) = \begin{cases} -1/2|x|3 + 5/2|x|2 - 4|x| + 2 & 1 \leq |x| < 2 \\ 0 & 2 < |x| \end{cases}$$

Where X is defined as the distance between interpolation point and grid point

D. Filtering-based(Re-sampling) Techniques

Transformation of image pixel from one coordinate to another with different resolution is called Re sampling process. Digital image is a discrete function in two dimensions so that we need 2D filtering or convolution. But it is computationally costly. We can separate the 2D function and it can be applied to its first row wise and then column wise on 1D. We have knowledge on different filters used for interpolation algorithm from the above concepts [1]. Blur and noise removal can done by using as well as edge identification. Some of the filters and website are listed below from which one can learn more about these filters.

Table 1: Filters and References

Filter	Reference
Michell cubic polynomial filters	www.mentallandscape.com/Papers_siggraph88.pdf cognitrn.psych.indiana.edu/busey/erp/DigFilt.pdf
Bell quadratic polynomial filter	http://www.sweetwater.com/expertcenter/glossary/t--BellFilter
Hermite cubic polynomial filter	http://en.wikipedia.org/wiki/Hermite_interpolation http://www.bionixwallpaper.com/help/faq/comparison.html
Lanczos3 sinc-based filter	en.wikipedia.org/wiki/Lanczos_resampling
Triangle Filter(linear based)	http://www2.statistics.com/resources/glossary/t/triangle.php http://www.bionixwallpaper.com/help/faq/comparison.html
Cubic B-spline filter	http://www.dannyruijters.nl/cubicinterpolation/ http://ieeexplore.ieee.org/xpl/login.jsp?D1163154

III. ADAPTIVE TECHNIQUES

The image feature like edge information, intensity value, and texture are considered in Adaptive techniques etc. The main drawback of Non-adaptive interpolation techniques like blurring edges or artifacts around edges and its only store the low frequency components of original image. The high frequency components should be preserved to receive better visual quality and this task can be possible with adaptive interpolation techniques. These techniques produce a better result when compared to than non- adaptive techniques but take more computational time.

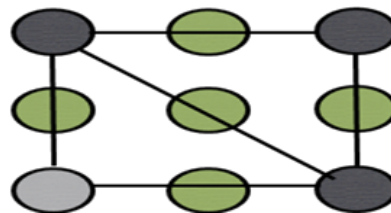


Fig II: Image mesh [16]

Various adaptive techniques are DDT, ICBI and many more.

A. Data Dependent Triangulation

The visual quality of image and the reduction in the computational complexity of image can be implemented using DDT. Data dependent triangulation interpolation technique improves with respect to other linear interpolation techniques. The main use of DDT is to overcome the disadvantages of bilinear interpolation technique.

In term of visual appearance DDT produce an effective result than bilinear interpolation and has a low computational complexity. DDT is better than other interpolation technique like NEDI, The following are the reasons:

1. DDT is as simple while the other techniques are complex. When we compared bilinear interpolation technique with DDT produce a good result.
2. Arbitrary enhancement and scaling DDT is used and in other techniques it is defined for magnifying [9].

Identify the triangles is the First step in DDT from four neighboring pixels. The pixels present in diagonal divide the four pixels into two triangle representation. Based on the edge present in the image [9] the Direction of diagonal are decided. Which triangle is best for our new pixels should be decided as a next process (consider one edge so it consist two pixels). Only on that three triangle vertices Interpolation should be applied, if the new pixels lie in the same triangle than first we store the edge direction of the four pixels in lookup table if the new pixels are not lies in the same triangle. Do inverse mapping each new pixel and decide remaining pixels for new pixels. The edge direction stores information and then decides the appropriate triangle to apply bilinear interpolation on that triangle to receive interpolated image.

The steps for DDT are as follows [16]:

Step 1: To calculate the edge for diving pixels into two triangles each set of four low resolution pixels is used.

Step 2: To store the direction of each edge create an image mesh

Step 3: Use linear interpolation within triangles

B. Iterative Curvature-based Interpolation

Iterative curvature-based interpolation techniques are mainly used to estimate the direction in which it is based on second order derivatives.

NEDI and other linear and non-linear interpolation techniques ICBI technique is used to minimize the artifacts presented in image and to compare other technique.

ICBI technique has lower cost for computational when compared with the other non-adaptive techniques. ICBI technique combines two techniques. Along the direction, new pixels are computed by using the first technique in interpolating (FCBI, Fast Curvature Based Interpolation). In the second technique, iterative method with energy term for edge preservation purpose is used to modify the interpolated pixels [2].

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

The energy term is the sum of the curvature continuity, enhancement and iso - levels curves in second technique. First we calculate, for each new pixel, the energy function $U(2i+1; 2j+1)$ and the two altered energies $U^+(2i+1; 2j+1)$ and $U^-(2i+1; 2j+1)$, in this the energy values are obtained by adding or subtracting a fixed value called threshold value to the local pixel value(i.e.) $I(2i+1; 2j+1)$ [2] and apply this intensity value to the pixel. This procedure can be repeated till we obtain the sum of the modified pixels at the current iteration is lower than a fixed threshold value. The ICBI technique's overall procedure as follows [2]:

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

Step 2: use FCBI method to insert pixels at locations $2i+1, 2j+1$.

Step 3: Till we receive the image variation is above a given threshold repeat the iterative method.

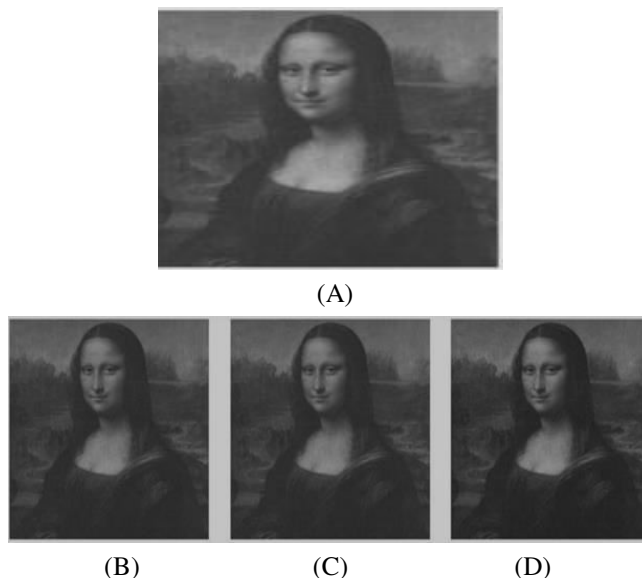
Step 4: In FCBI methods, to insert the pixels in the remaining locations.

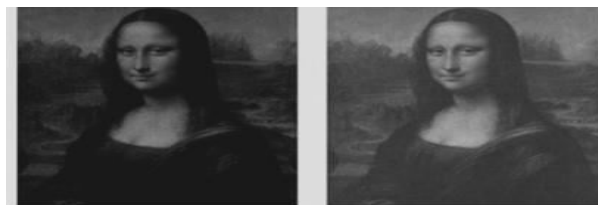
Step 5: To apply the correction in the added pixels

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

I. COMPARISION OF INTERPOLATION ALGORITHMS

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





(E)

(F)

Fig III: Comparison of images. (I) Original image, (II) Nearest neighbor, (III) Bilinear, (IV) Bicubic, (V) DDT, (VI) ICBI. [16][3][2]

From the below given table the comparisons of all images are shown with respect to its PSNR ratio (in dB):

Analysis table with PSNR ratio [16][3][2]

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

IV. CONCLUSION AND FUTURE WORK

In this paper we have studied and received an idea about the study of various image interpolation techniques like non-adaptive and adaptive techniques. We also made a study that adaptive techniques are better when we use it in terms of visual appearance of image but it takes more computational time. We choose the adaptive technique otherwise non-adaptive techniques are preferable when time is not considered as an obstacle in interpolation. We can alternatively use these interpolation techniques in our application.

In future, we combine these adaptive and non-adaptive techniques in order to overcome their individual disadvantages and make the resulting image better in terms of visual appearance and also in terms of computational timing.

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