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Comparison of Various Interpolation Based Image Zooming Techniques

Ritu Dhingra*, Singara Singh
SMCA,Thapar University,Patiala
Punjab, India

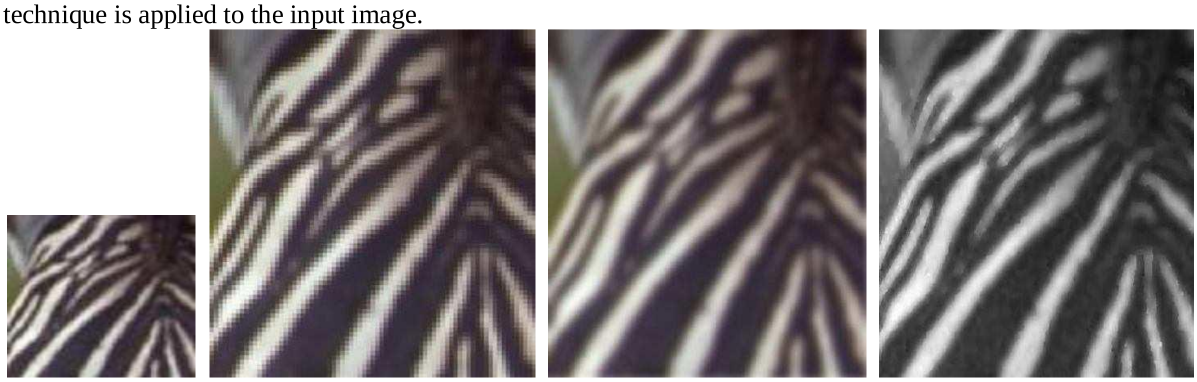
Abstract—This paper proposes an overview of all the existing interpolation based image zooming techniques .There are various techniques ranging from traditional nearest neighbour, bilinear interpolation, cubic interpolation, spline interpolation to the fuzzy logic based image zooming techniques. Every interpolation techniques has its own advantages and disadvantages.In this paper, a comparison between various interpolation based image zooming techniques based on the PSNR is for various images.

Keywords— Interpolation, Image Zooming, Scaling, PSNR, Artifacts

I. INTRODUCTION

Image zooming is enlargement or magnification of images for better view. It is the process of increasing pixels of an image. When an image is zoomed by an image zooming technique, an enlarged output image is obtained. It is applied in diverse areas ranging from computer graphics, rendering, editing, medical image reconstruction and online image viewing. However while performing various transformations, speed and efficiency needs a balance. There are various interpolation based image zooming methods like simplest nearest neighbour in which the gray level value is calculated from the nearest pixel value, is the fastest of all but the zoomed image is blocky and jagged. The Bilinear and Bicubic interpolation uses the first order and second order combination of original pixels in order to get the new pixels in the zoomed image. In the interpolation based image zooming techniques, the time complexity increases along with the quality but Ringing artifacts introduce blurriness in image. In spline Interpolation fitted spline provides intensity values for the generated pixels and in this edges are not clear and the remaining artifacts are not there. Peak Signal to Noise Ratio is a measure to evaluate the quality of zoomed image. PSNR is a quantitative measure, which is used to compare the quality of an original and zoomed image.

There are various artifacts like jaggies, ghosting and blurriness that gets generated when an interpolating technique is applied to the input image.



(a) (b) (c) (d)
Figure 1.(a)Original Image (b)Image with Jaggies (c)Image with blurring (d) Image with ghosting

These artifacts are shown in figure 1 Jagging are the blocks are formed due to replication of pixels, Blurring is the unclearity of the image, Ghosting is the distortion of the image. The interpolation techniques attempt to solve these artifacts in many ways. So this paper gives a clear vision of the various interpolating techniques and the comparison of all the techniques in terms of PSNR.

II. Related Work

In this section, various image zooming techniques are discussed in brief.

2.1.1 Linear Techniques

Linear techniques ([1]–[4]), use linear space-invariant filters to interpolate the high-resolution samples of zoomed image. Common choices of interpolation filter are nearest neighbour, bilinear, bicubic, quadratic, Gaussian and various types of spline functions [1]. Since the theory behind linear interpolation is well established, most of the research on this approach is focused on finding new filters which reduce artifacts introduced by the traditional filters, as well as more efficient implementations. In [2], a modified version of the B-spline is used to obtain interpolation filters with better frequency responses, [3] proposes a filter design method that attempts to account for the properties of human visual system, and [4] develops non-separable cubic convolution kernels to replace the traditional separable cubic filter. Due to the relative simplicity and efficiency of linear interpolation techniques, they are the most common approach provided by commercial software packages such as Adobe PhotoShop and MATLAB.

2.1.2 Non - Linear Techniques

Non-linear techniques, ([5]–[7]), use non-linear optimization processes constrained by certain image features. In [5], a technique which optimizes a convex cost function based on an approximation of the gradient of the high-resolution image from the low-resolution image is presented. This technique attempts to preserve edges by adding constraints on their orientation. A different approach is taken by [6], in which the problem is viewed from a geometric perspective. In this technique, an image is first linearly interpolated. Then spatial regions of constant intensity are warped such that level curves are smoothed, thereby sharpening boundaries between regions. In [7], a regularized image interpolation technique is proposed which focuses on the correct modelling of the image acquisition and display processes.

2.1.3 Transform Techniques

Transform techniques ([8], [9]), are primarily focused on the use of multi-resolution decomposition, followed by interpolation applied to each level of the decomposition and/or extrapolation of higher resolution levels. These approaches aim at synthesizing the high frequency components of the magnified image by adapting the interpolation to suit the frequency content contained at each level of decomposition. In [8], higher resolution levels of Laplacian pyramid decomposition are extrapolated from lower ones. Another approach, taken by [9], makes use of a filter bank which extracts edge directional components from the low resolution image and interpolates each sub-band in a directional specific way as to enhance the edges it contains.

2.1.4 Statistical Techniques

Statistical techniques ([10, 11]),estimate the high-resolution image on the basis of properties of the given low-resolution image. In [10], the high-resolution image is modelled by a Gibbs-Markov random field with specially selected clique potentials to classify the properties of each neighbourhood. The chosen potentials allow the classification of pixels by degrees of smoothness or discontinuity, thereby being able to properly handle edges. Another approach creates a set of pixel classifications gathered from the statistics of pixels in typical training images [11]. Once trained, the technique interpolates an image by estimating the best filter coefficients (in the mean-square sense) for each neighbourhood. From these four categories, only the first is non- adaptive technique. Non-linear and statistical techniques have found greater use in highly specialized applications such as super-resolution, where a sequence of video frames are combined to form a single, high-resolution image, and medical imaging, where the techniques are tied to the underlying physics of the image-acquisition process or are highly constrained by prior knowledge of image features.

2.2 Algorithm Subdivision

Common interpolation techniques can be grouped into two categories: adaptive and non-adaptive. Adaptive techniques change depending on what they are interpolating (sharp edges vs. smooth texture), whereas non-adaptive techniques treat all pixels of the image equally.

2.2.1 Non-Adaptive Techniques

It include: nearest neighbour, bilinear, bicubic and others. Depending on their complexity, these use adjacent pixels when interpolating. The more adjacent pixels they include, the more accurate they can become, but this comes at the expense of much longer processing time. These techniques can be used to both distort and resize a photo.

2.2.2 Adaptive Techniques:

It includes many proprietary techniques in licensed software such as: Qimage, Photo Zoom Pro, Genuine Fractals and others. Many of these apply a different version of their technique (on a pixel-by-pixel basis) when they detect the presence of an edge aiming to minimize unsightly interpolation artifacts in regions where they are most apparent. These techniques are primarily designed to maximize artifact-free detail in enlarged photos, so some cannot be used to distort or rotate an image.

II. COMPARISON AND EVALUATION NEAREST NEIGHBOR INTERPOLATION

The simplest interpolation technique is to locate the nearest data value, and assign the same value. Interpolation is the problem of approximating the value of a function for a non-given point in some space when given the value of that function in points around (neighboring) that point. The nearest neighbor algorithm selects the value of the nearest point and does not consider the values of neighboring points at all, yielding a piecewise-constant interpolant. The technique is very simple to implement and is commonly used (usually along with mipmapping) in real time 3D rendering to select color values for a textured surface. In simple problems, this technique is unlikely to be used, as linear interpolation is almost as easy, but in higher dimensional multivariate interpolation, this could be a favorable choice for its speed and simplicity.

Linear interpolation : If [12] the two known points are given by the coordinates (x_0, y_0) and (x_1, y_1) refer fig.2 , the linear interpolant is the straight line between these points. For a value *x* in the interval (x_0, x_1), the value *y* along the straight line is given from the equation

$$\frac{y - y0}{x - x0} = (y1 - y0)/(x1 - x0)$$

which can be derived geometrically from the figure on the right. It is a special case of polynomial interpolation with $n = 1$.
Solving this equation for *y*, which is the unknown value at *x*, gives

$$y = y0 + (y1 - y0) \times (x - x0)/(x1 - x0)$$

which is the formula for linear interpolation in the interval (x0,x1). Outside this interval, the formula is identical to linear extrapolation. This formula can also be understood as a weighted average[5]. The weights are inversely related to the distance from the end points to the unknown point; the closer point has more influence than the farther point. Thus, the weights are $(x - x0)/(x1 - x0)$ and $(x1 - x)/(x1 - x0)$,which are normalized distances between the unknown point and each of the end points.

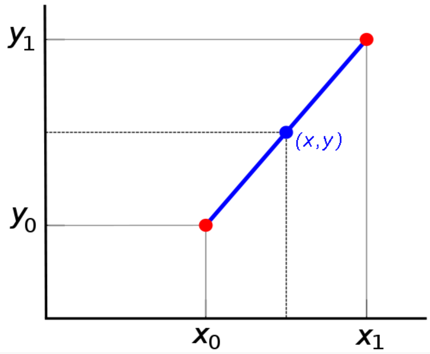


Figure.2Given the two red points, the blue line is the linear interpolant between the points, and the value *y* at *x* may be found by linear interpolation

Bicubic Interpolation: Bicubic goes one step beyond bilinear by considering the closest 4×4 neighbourhood of known pixels of the image. Since these are at various distances from the unknown pixel, closer pixels are given a higher weighting in the calculation. Bicubic produces noticeably sharper images than the nearest-neighbour and bilinear interpolation, and is perhaps the ideal combination of processing time and output quality. For this reason it is a standard in many image editing programs (including Adobe Photoshop), printer drivers and in-camera interpolation. Bicubic Interpolation uses the same principle as Bilinear Interpolation, except using a cubic function instead of a linear function to estimate pixels between known values . This form of interpolation has advantages and drawbacks over Bilinear Interpolation. First, calculating the cubic polynomial in a specific area of the image is more computationally expensive than simple linear fits and also requires a larger neighbourhood to calculate the curve. However, since Bicubic Interpolation utilizes a cubic curve, blurring is not as pronounced as in Bilinear Interpolation. That is because pixel value transitions can be more rapid on the curve. A linear function fits straight lines between known points, and a cubic function fits cubic splines. On the other hand, jaggies are more distinguished since the image isn't as blurred.

Spline Interpolation: In the mathematical field of numerical analysis, spline interpolation is a for the interpolation where the interpolant is a special type of piecewise polynomial called a spline. Spline interpolation is preferred over polynomial interpolation because the interpolation error can be made small even when using low degree polynomials for the spline. Spline interpolation avoids the problem of Runge's phenomenon, which occurs when interpolating between equidistant points with high degree polynomial.
Like polynomial interpolation, spline interpolation gives a smaller error than linear interpolation and the interpolant is smoother. However, the interpolant is easier to evaluate than the high-degree polynomials used in polynomial interpolation.

IV. Results

The quality of enlarged images depends on the type of interpolation technique used in zooming technique. To get an enlarged image programs using MATLAB were developed where various images were given as input and zoomed image were obtained . PSNR is calculated for these images.The quality of enlarged image is the best using spline interpolation among the used image zooming techniques

Table I
Comparison Between Peak Signal To Noise Ratio for Different Images Using Various Interpolation Techniques

Image Name	Nearest-Neighbor	Blinear	Bicubic	Spline
Lena	11.0954	24.2183	25.3103	26.7891

Pepper	9.5032	23.0918	25.2015	26.7098
Barbara	22.9947	24.4120	25.5123	26.6134
Grayscale Baboon	19.0432	21.0245	23.0987	25.6798
Couple	25.2937	27.1134	27.1134	28.6214
Bridge	22.6750	23.2185	25.3867	26.0987
Airplane	25.1020	26.3424	26.9876	28.3746
Boat	25.5147	27.4693	28.2164	30.1603
Zelda	29.4968	31.8532	32.6143	34.0183
Sailboat	25.6794	26.8817	27.5143	29.1063

The results are based on the algorithm applied on the different images using MATLAB. The table clearly reflects that the PSNR value of the spline interpolation is the highest among the nearest-neighbour, Bilinear, Bicubic and Spline interpolation.

V. Conclusion

In this paper various interpolation based image zooming techniques are discussed. Each interpolation technique has its own advantages and disadvantages, some are inferior in quality while some are weal with the time that occurs to get the enlarged image as an output. Apart from implementation of these techniques, a comparative study was made on the enlarged image that was received as an output. This comparison was made on the basis of PSNR of various images that was calculated.

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