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State of the Art in the Field of Hardware Implementable Image Resizing Applications

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ABSTRACT

Image zooming is a principal image processing operations. JPEG methods are acceptable standards while it is among lossy methods, but still produce acceptable quality outcome. Zooming deals with resizing images in search of details, increased resolutions, for optics, printing or generic image processing [4,1]. The uses of image interpolation are generic viewing of online images up to the magnification of satellite images

This paper presents a review of all the prevalent techniques for zooming of images. Lot of appreciable work has already been done in this field. Our objective is to review the prevalent work and look for a better alternative. We concluded that bulks of the algorithms are based on traditional methods, but we have shifted our focus to adaptive methods. The traditional methods have many issues, and they have been discussed here. The paper has reviewed most of the interpolation based techniques along with real world examples. However, there isn't much relevant literature on adaptive zooming methods.

Many interpolation algorithms currently being used commercially produce magnifications that include undesirable issues like blurring, jaggies and ghosting, and that's why we need a more comprehensive interpolation technique that can eradicate these flaws.

KEYWORDS: *Image resizing, Interpolation, Image blurring, Image zooming*

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I. INTRODUCTION

Image zooming within Multi Media is a prominent process in image processing.

Zooming predominantly means changing the number of pixels on display/image only in appearance. At Zooming factor = 1, there is one display pixel per image pixel. Likewise at 2, there are 2 display pixels per image pixel in both x and y. This enlargement is mentioned by a calculated number greater than one, called magnification factor. Reduction in size can be attributed when this number is less than one and that is called minification.

Image zooming being one of the most fundamental image processing operations, is very commonly used. JPEG Standards are usually acceptable standards but are considered as lossy methods, with good quality outcome. Zooming in simplest terms is resizing of images in requirement for more detail, added resolution, use of optics, digital printing or signal processing [4,1]. The uses of image interpolation are from general viewing of images to more elaborate uses in satellite images. With the advent of commercial digital photography, users now want more processing options associated digital images. Astral images from satellites are received at minimal transmission rates of the order of 40 bytes per second, making the transmission of High Resolution data impractical. For medical applications, neurologists want the capability to zoom in on particular areas for brain tomography analysis. Zooming has video applications in resizing a video frame so that it fits the field of view of a projection device, which in the end reduces blurring, Finally, the most obvious use of image zooming is to have a magnified version of an important image taken from any digital imaging device like a camera, digital camera, digital camcorder or scanner.

Conventional image zoom mechanisms make use of up sampling by zero insertion and then employ one dimensional filter for interpolation of the high resolution samples. The main issue with this approach is that the spectral content of the HR image and the LR image are overlapping. This is because linear techniques are not able to add new information in the image resulting in a variety of unwanted image artifacts such as blocking, staircase edges and blurring.

II. INTERPOLATION IN IMAGE ZOOMING

The restoration of degraded images can be applied in many application areas that are needed to repair images with Image interpolation being a significant part of image restoration. Data is presented in a regular grid or on a line with the program needing to compute values at arbitrary position on that grid [1].

Interpolation or resampling is an imaging method to increase or decrease the pixel count in digital images [3]. The applications range from handling computer graphics to medical image applications, or just simple online image viewing.

Interpolation uses simpler functions like polynomials. This allows inputs to be computed at random input positions not limited to sample points. The objective of image interpolation is to produce good quality images at various resolutions from a single Low resolution image. Number of pixels define the actual resolution of a particular image, however the effective resolution is a much more difficult quantity to be precisely calculated because of the fact that it depends on perceptive human analysis.

The image quality is a function of used interpolation technique. Image interpolation works bidirectionally, and tries to approximate a pixel's color and intensity on the basis of the adjoining pixel values. The given example exemplifies resizing.

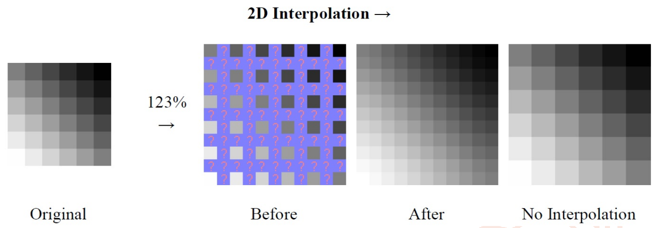


Fig 1.Resizing / enlargement works

Magnification involves enlarging in appearance, but not in actual physical size. This is measured by a computed number also called "magnification factor". In general, magnification can be classified as

1. Linear or transverse magnification: For real images, such as images projected on a screen, size is a linear quantity
2. Angular magnification : Placement of the object closer to least distance of distinct vision. Here tangent of the angle is considered.

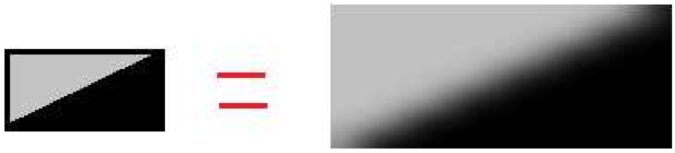
III. IMAGE INTERPOLATION TECHNIQUES

Common interpolation mechanisms are grouped into two categories: adaptive and non adaptive. Adaptive methods change are based on what they are interpolating while non adaptive methods consider equal treatment of all pixels.

3.1. Non-Adaptive Algorithms

Non adaptive interpolation is done using static pattern for entire pixels and has the distinct advantage of ease of computation and low cost [2]. Based on complexity, Any pixels ranging from 0 to 256 which are adjacent pixels are used when interpolating. Accuracy increases with the number of adjacent pixels that are included, however the computation times increase in this manner. The algorithms are made use of in resizing a photo. The zoomed image of Figure 2(a) using non adaptive algorithm is shown in Figure 2(b). Non-adaptive algorithms are:

1. Nearest Neighbor
2. Bilinear
3. Bicubic Smoother
4. Bicubic
5. Bicubic Sharper
6. Lanczos
7. Bilinear blur



(a) Test Image (b) Bilinear b/w Blur
Fig 2: Enlarged Image using Non-Adaptive Algorithm

3.2. Adaptive Algorithms:

Adaptive interpolation involves estimation of lost pixel values using adjoining pixels as well [21]. But with increased computations. Many apply an altered version of their algorithm pixel wise to detect the presence of an edge in order to to minimize interpolation errors in regions where they are most visible. The algorithms maximise error free details in zoomed photos, but some cannot be used to rotate an image. Adaptive algorithms are:

1. Nearest Neighbor
2. Bicubic
3. Genuine Fractals
4. Photo Zoom
5. Smart Edge

3.3. Interpolation Methods

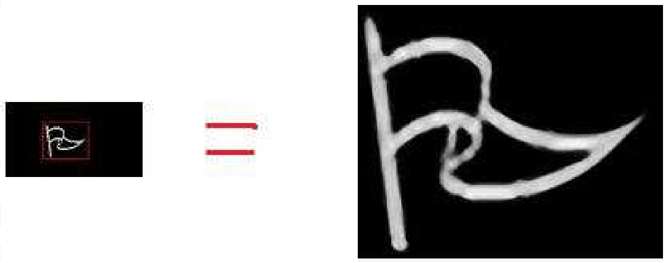


Figure 3: Enlarged Image using Adaptive Algorithm

3.4. Interpolation Methods

Interpolation is used to make a small image larger. Software tools are utilized to stretch the image and fill generated pixels in the blanks. Interpolation involves the estimation of values in a function between known points. If images are Interpolated they produce smoother lines with better print than original, small image. There are various function fitting or interpolation methods, namely pixel replication, bilinear interpolation, and bicubic interpolation.

3.4.1. Pixel Replication

Pixel replication is primary interpolation from a computational view where the nearest neighbor, of each interpolated pixel is given the computed value of the closest input image sample point. This technique also called as the point shift algorithm and pixel replication is a very commonly used technique. The nearest neighbor interpolation kernel is calculated through the spectral response of the nearest neighbor kernel

The kernel and its Fourier transform are shown in Figure 4

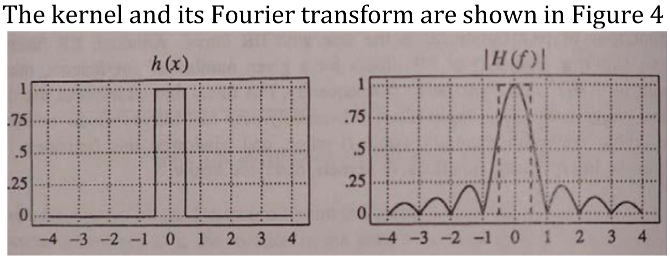


Figure 4: Kernel and its Fourier transform

(a) Down sampled image (b) 3× Pixel Replication image (c) Original Image
Figure 5: Pixel Replication Example

A type of up sampled digital image by incrementing the pixel count in an image, but without adding any data or detail is given in fig. In Figure 5, the original image down sampled by a ratio of three Figure 5 (a) then again magnified 3 times by employing pixel replication. The colored pixels are have been interpolated making use of original pixel content. Image quality is of moderate quality levels when zooming in this manner. As shown in Figure 5(b), images generated with pixel replication are extremely jagged, resulting in the HR image also being blocky and jagged. This is due to the reason that the original pixels have been magnified exactly the same magnification scale.

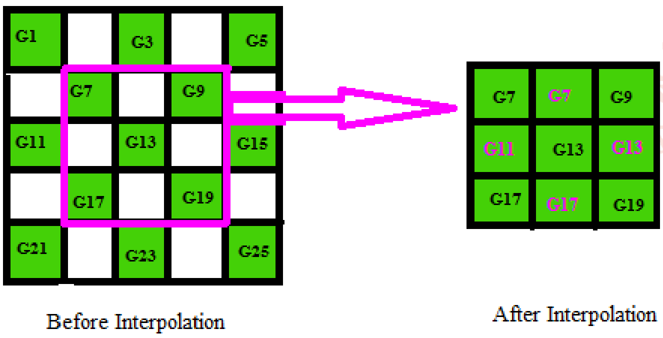


Figure 6: Pixel Replication Working

The above Figure 6 shows working principle of pixel replication. A selected part of the given image is magnified 2 times in the given pattern resulting in image Y.

3.4.2. Bilinear Interpolation

Bilinear interpolation is an enhancement over linear interpolation and have include interpolation of functions of two variables on a regular grid. The interpolated function shouldn't include the term of x^2 and y^2 but product of xy, which is actually the bilinear form of x and y.

Bilinear interpolation makes use of the closest 2 by 2 adjacent neighborhood of pixel values around the unknown pixel. A weighted average of these 4 pixels is then taken to finally achieve the final interpolated value.

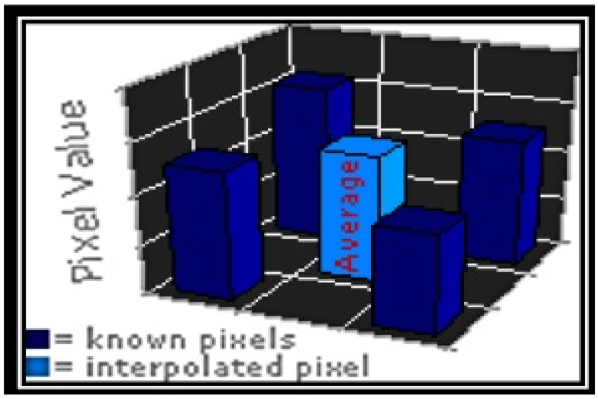


Figure 7: Bilinear Interpolation

In this way better images are obtained in comparison to nearest neighbor interpolation.[22] Weight is computed by allotting fixed value of 4 nearest neighbor pixel to generated output pixel. Each weighed value is in direct proportions to the distance from existing pixels. This mechanism has the advantage of ease of calculation. The final image using bilinear interpolation is much better than nearest neighbor pixel replication mechanism. However, this results in blurring effect as a result of averaging of surrounding pixels. Figure 8 presents an example of linear interpolation in 1D. Here, unknown pixel values in the HR grid are computed to fall on the same line between two original pixel values.

A linear function is supposed to be a fit between known values and all interpolated values falling on the bestfit line.

Like, in double magnification in 1D, only one unknown pixel between known pixel values is used. The pixel value is then calculated by using half of the known pixels and then half of the second known pixels. Here, interpolation is performed one dimensionally. Linear interpolation is also used for two dimensions. Bilinear interpolation can be termed as linear interpolation in 1D followed by linear interpolation in other dimension.

Like if estimation of a pixel between a block of four original values is to be done, then two temporary values are done; top pair of pixels interpolated linearly and secondly, the bottom pair of pixels interpolated in a similar manner. Finally, a linear interpolation is performed between the two temporary values.

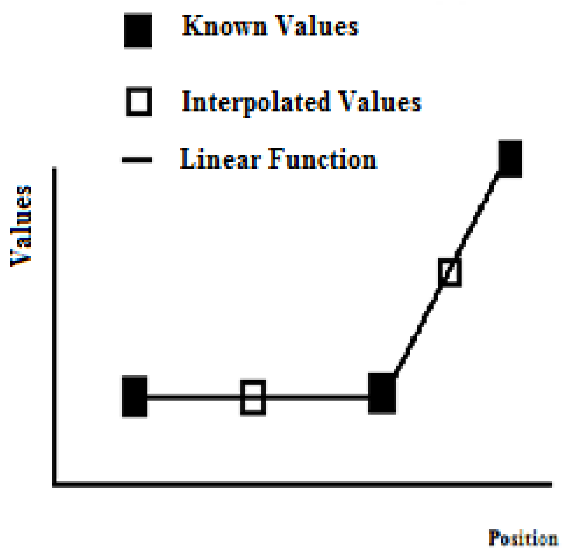


Figure 8: Linear Interpolation

(a) Down Sampled image (b) Pixel replication image

(c) 3× Bilinear image (d) Original image

Fig 9 Results of Bilinear interpolation for various sizes

In Figure 9, original image Figure 9(d) is shown as a down sampled image by 3 Next figure then showsa one magnified 3 times bilinear interpolations. As already discussed, Bilinear interpolation produce smoother images than nearest neighbor method. This can be seen in Figure 9. The interpolation process has resulted in a slightly blurred image since pixel values are distributed throughout the HR grid.

3.4.3. Bicubic Interpolation

Bicubic interpolation extends cubic interpolation for interpolating data points on a 2D regular grid. This results in much more smoother surfaces as obtained by bilinear interpolation or nearest neighbor interpolation. Bicubic interpolation makes use of information from actual pixel plus sixteen of the adjoining pixels to compute the color of the new pixels generated from the original pixel. This has shown considerable improvement over the previous two interpolation methods for two reasons for the fact that it uses data from a much larger number of pixels and also because of the fact that it uses a bicubic calculation more enhanced than the calculations of the previous interpolation methods as shown in Fig 10. The method produces photo quality results hence one of the method most commonly used methods.

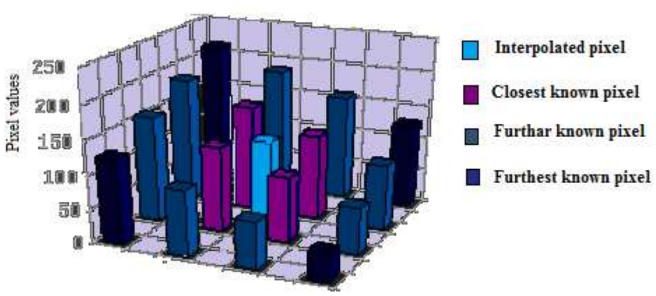


Figure 10 : Bicubic Interpolation

Bicubic interpolation works similarly, with the difference of a cubic function instead of a linear function to estimate pixels between known values as in Figure 11. This high pixel interpolation produces great outputs, speed and quality wise. This form of interpolation has significant advantages as well as drawbacks over bilinear interpolation. First, cubic polynomial is calculated in a specific area of the image. This is more computationally exhaustive and costly than simple linear fits and also requires a larger neighbor to calculate the curve. A linear function on the other hand fits straight lines in known points while a cubic function fits cubic splines. On the other hand, jaggies are more distinguished since the image isn't as blurred

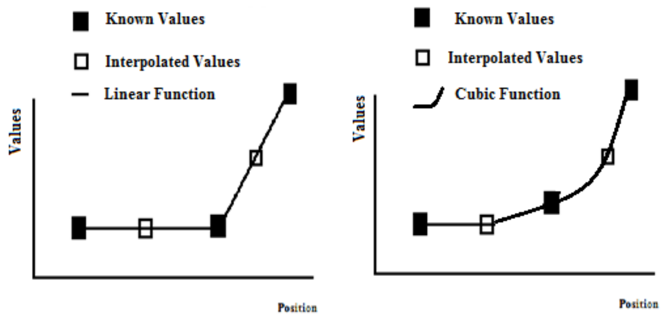


Figure 11: Linear vs Bicubic Interpolation

A comparison of bilinear and bicubic interpolation is shown in Figure 12. In Figure 12, original image Figure 12(d) down sampled by a scale of four as shown in Figure 12(a) then magnified 3 × bicubic interpolations in Figure 12(c). Bicubic interpolation produces magnifications, which are sharper and more jagged (Lena for example) than bilinear interpolation.

(a) Down sampled image (b) 3x Bilinear image

(c) 3x Bicubic image (d) Original image

Figure 12: Bilinear vs Bicubic Interpolation.

3.4.4. Filtering Methods

Some other magnification techniques use filtering approaches for LR images. Filter based mechanisms use sampling theory to attempt to create perfect interpolations of images. By convolving these pixel points with a sinc function in the spatial domain, a perfect reconstruction of sampled points is accomplished.

Due to these approximations, errors are introduced causing both blurring and jaggies. Another drawback of using filter based methods is the increase in computational cost. With a shortened sinc function, the kernel still assumes large proportions. i.e, the Lanczos filter which is a windowed derivative of the sinc filter. The sinc function cant be used directly due to its infinite extent. However, approximated or windowed version of the filters, can be used and the Lanczos filter is one such version. The windows exist in a range and vanish outside it, thereby using larger ranges and improving accuracy in trade of computation. The Lanczos2 and Lanczos3 filter's 16X16 kernel, makes the algorithm computationally intensive as compared to bicubic interpolation.

IV. VISUAL PROPERTIES OF INTERPOLATED IMAGES

1. Geometric Invariance: The content should not get altered due to interpolation methods to preserve the geometry and sizes.
2. Contrast Invariance: The method should safeguard luminosity content of an image and also contrast of the image.
3. Noise: The method should not result in addition of noise.
4. Edge Preserving: The method has to maintain edges and boundaries with sharpness.
5. Aliasing: The method should not result in staircased edges.
6. Texture maintenance: The method should not result in blurred regions.
7. Over smoothing: The method should not cause unwanted blocky regions.
8. Application Awareness: The method should give standard results as per image and its resolution.
9. Sensitivity Parameters: The method should not not affect the internal parameters that are different for different images.

V. VLSI ARCHITECTURES FOR IMAGE INTERPOLATION

VLSI system is implemented in FPGA or ASIC. FPGA is configured by a designer. Thus, FPGAs can make high performance reconfigurable computing systems at low costs. ASIC's on the other hand are not reconfigurable. Modern FPGA platforms have millions of gates, in Ghz clock frequency, sufficient on chip memory and fast IO's [24]. FPGAs can be utilised for real time implementation of motion detection, image enhancement, image correlation, and image compression.

5.1. Digital Image Scaling Algorithm

Andread is and Amantiad is presented an image interpolation algorithm for monochrome and RGB of any different resolutions and scaling factors [25]. This used a mask of four pixels and computed the end luminescence/pixel joining percentage of area that mask covers from every source pixel and the luminosity difference between the source pixels. This interpolation works on linear area domain and with continuous area filtering and hence able to perform upscale and downscale processes simultaneously for fast real time applications. The algorithm has been implemented on Quartus II FPGA with mentioned frequency of 55MHz with interpolation making use of 20 additions and 13 multiplications. The computed RMSE has been found to be less than the RMSE of rival interpolation schemes like nearest neighbour, bilinear, and winscale.

VI. CONCLUSION

This paper presented a review of the past and recent works in the field of Image interpolation with a hardware perspective. We have discussed various interpolation mechanisms like Bilinear, Bicubic and Linear.

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