ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2014

A Review: Image Interpolation Techniques for Image Scaling

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ABSTRACT: The growing interest in image scaling is mainly due to the availability of digital imaging devices such as, digital cameras, digital camcorders, 3G mobile handsets, high definition monitors etc. Scaling a digital image is a demanding and very important area of research. Image scaling is an important image processing operation applied in diverse areas in computer graphics. Image scaling can be especially useful when one needs to reduce image file size for email and web documents or increase image size for printing, GIS observation, medical diagnostic etc. With the recent advances in imaging technology, digital images have become an important component of media distribution. In addition, a variety of displays can be used for image viewing, ranging fromhigh-resolution computer monitors to TV screens and low-resolution mobile devices.This paper is focused on different image scaling techniqueswith intent that review to be useful to researchers and practitioners interested in image Scaling.

KEYWORDS: Image Scaling, interpolation, Non-adaptive techniques, adaptive techniques, Context aware image resizing, Segmentation-Based, Seam Carving, Warping-Based Methods.

I. INTRODUCTION

Technology for display devices are growing very fast, an image often needs to be displayed across various size with different aspect ratios. Images are frequently used in news stories, and people post their pictures online to be seen by family and friends on social network sites such as facebook and tweeter or on mobile applications such as WhatsApp and WeChat. To maintain desirable visual quality of an image across all conditions, a proper way of scaling is required. As a result, image scaling for different visual device has been an active research topic recently.An image records the visual information of the covered scene taken from a camera from a certain angle. When rescaled to a different setting such as size, resolution or aspect ratio, the original visual contents will be changed [10]. To preserve the important contents as the original, researcher have developed different image interpolation techniques with each having some advantages and disadvantages over other.

II. IMAGE INTERPOLATION TECHNIQUES

Interpolation is way through which images are scaled. There are many different types of interpolation methods, each resulting in a different look to final image. Thus, it is best if the quality, or visible distinction for each pixel, is retained throughout the scaling process [13].

Image interpolation works in two directions, and tries to achieve a best approximation of a pixel's color and intensity based on the values at surrounding pixels [8]. Fig. 1 illustrates how scaling/resizing using two dimensional image interpolation works:

Interpolation techniques are mainly divided in two categories:

A. Non-adaptive techniques
B. Adaptive techniques

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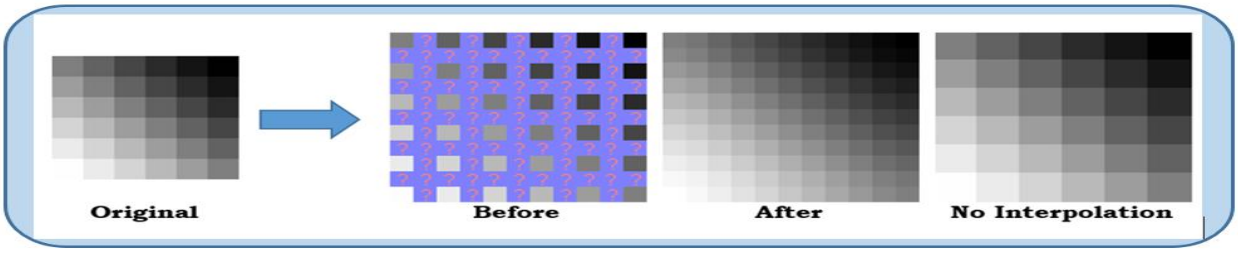

Fig.1. Two Dimensional Image Interpolation

A. *Non-adaptive techniques:*

Non-adaptive interpolation techniques are based on direct manipulation on pixels instead of considering any feature or content of an image [3]. 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, Lanczos, Sinc etc.

i. *Nearest Neighbor:*This is the simplest and requires the least processing time of all the interpolation algorithms. Nearest neighbor selects the value of the nearest pixel by rounding the coordinates of the desired interpolation point. Using this method one finds the closest corresponding pixel in the source (original) image for each pixel in the destination image [5]. New pixels are made the same as others close-by. The pixels or dots of color are duplicated to create new pixels as the image grows. It creates pixilation or edges that break up curves into steps or jagged edges. This form of interpolation suffers from normally unacceptable effects for both enlarging and reduction of images. The interpolation kernel for nearest neighbor interpolation is[11]:

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

Where **x** = distance between interpolated point and grid point.

ii. *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. 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[14]:

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

Where **x** = distance between interpolated point and grid point.

iii. *Bicubic Interpolation:*Bicubic goes one step beyond bilinear by considering the closest 4x4 neighborhood of known pixels for a total of 16 pixels. 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 previous two methods, 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.The interpolation kernel for bicubic interpolation is[14]:

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

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Where **x** = distance between interpolated point and grid point.

iv. *Bicubic B-Spline:*As bicubic interpolation, the bicubic B-spline interpolation algorithm also interpolates from the nearest sixteen source pixels. However, this algorithm uses B-spline interpolating functions instead of cubic splines, which in general yield quite smooth results. It performs a convolution with a two-dimensional non separable filter, so its complexity is increased. In contrast, bicubic interpolation uses a convolution with a separable filter, and hence its complexity is less. Despite this performance difference, bicubic B-spline has interesting characteristics of smoothness that make it a good option in some cases. The interpolation kernel for Bicubic B-Splince interpolation is [5]:

$$u(x) = 1/6 \begin{cases} 3|x|^3 - 6|x|^2 + 4 & 0<=|x| < 1 \\ -|x|^3 + 6|x|^2 - 12|x| + 8 & 1<= |x|<2 \\ 0 & 2 <= |x| \end{cases}$$

Where **x** = distance between interpolated point and grid point.

v. *Lanczos interpolation:*Lanczos interpolation function is a mathematical formula used to smoothly interpolate the value of a digital image between its samples. It maps each sample of the given image to a translated and scaled copy of the Lanczos kernel, which is a sinc function windowed by the central hump of a dilated sinc function. The sum of these translated and scaled kernels is then evaluated at the desired pixel. Lanczos interpolation has the best properties in terms of detail preservation and minimal generation of aliasing artifacts for geometric transformations not involving strong down sampling. The Lanczos interpolation function of order n in one dimension is given by[6]:

$$L(x,n>0) = \begin{cases} \text{sinc}(x).\text{sinc}(x/n) & \text{for } |x| <=n \\ 0 & \text{otherwise} \end{cases}$$

Where the normalized sinc function is:

$$\text{sinc}(x) = \begin{cases} 1 & \text{for } x=0 \\ \sin(\pi x)/(\pi x) & \text{otherwise} \end{cases}$$

vi. *Sinc interpolation:*Sinc interpolation is advance Lanczos interpolation functions of orders 3, 4 and 5 is shown in Fig. 2.It uses more complex sinc function to smoothly interpolate the value of a digital image. Sinc algorithm produce the best results; it is able to resolve detail all the way to the theoretical maximum, while still maintaining the fewest artifacts. In image scaling, a sinc filter is an idealized filter that removes all image components above a given cutoff level, without affecting other image detail, and has linear phase response. These algorithms are primarily designed to maximize artifact-free detail in enlarged photos, it cannot be used to distort or rotate an image [7].

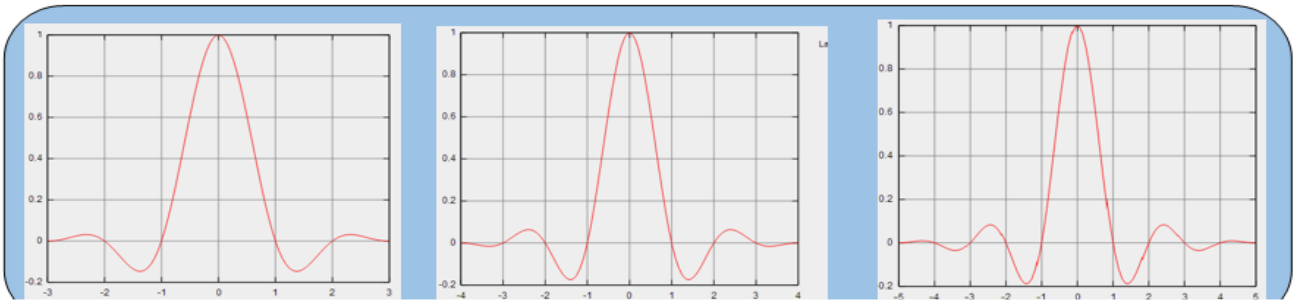

Fig.2.Sinc interpolation functions of orders 3, 4 and 5

During image scaling pixel values can change far more abruptly from one location to the next. The more you know about the surrounding pixels, the better the interpolation will become. Therefore results quickly deteriorate as we

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stretch an image, and interpolation can never add detail to your image which is not already present [12].The result of different image interpolation techniques discussed so far are shown in Fig. 3.

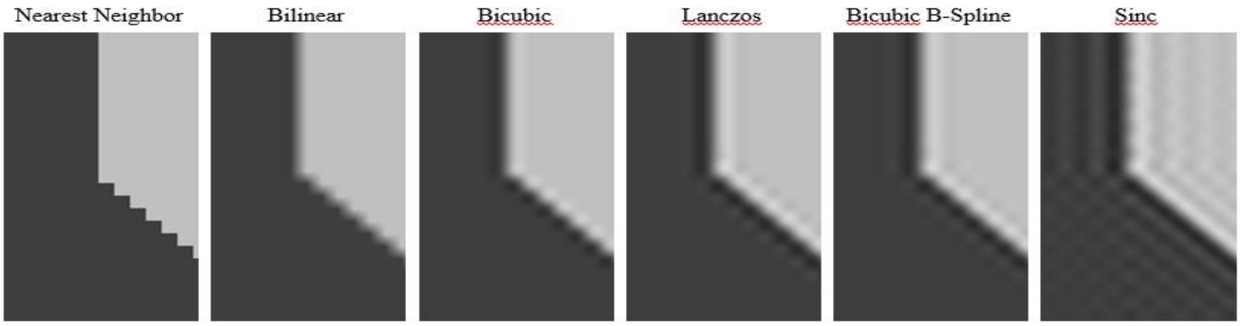

Fig.2.Linear interpolation of a step edge: a balance between staircase artifacts and ripples [12].

B. *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 [8]. Various adaptive techniques are Context aware resizing, segment based, seam carving, wrapping based etc.

i. *Context aware image resizing:*There are many techniques proposed for context aware image resize by different researchers. Using these techniques it allows image size to be changed for cropping image, but does not fix the size of output image. In this group of techniques Suhet al.[17], suggestedthat the objects in an image is important in many retrieval tasks. The main objective is, before scaling an image it automatically crop images to create thumbnail. In this method they compute a saliency map and calculate cropping window using greedy search. This saliency map act as criteria of importance for image resize. An image with human face is simply cropped regions with the face detection.Zhang et al.[19] performs cropping of an image by an optimization problem, in which the objective function is defined as the sum of three sub model energies, i.e. sub model for energy of composition, sub model for energy of conservative and sub model for energy of penalty. Particle swarmoptimization (PSO) is then utilized to obtain the optimal solution by maximizing the objective function. The candidate solution which maximizes the objective function will be the final cropping result.Ciocca et al.[4] initially classify the different images according to its semantic types i.e. nature, close-up face image and others using CART classifier.Then they crop images by applying different algorithms base on the image semantic types. Natural and landscape images not changed, close-up face images are cropped using saliency map for skin color and face regions. Other image types are first checked for face using face detector application, if no face is detected it is cropped using saliency map.Stentiford[16] propose cropping an image based on the using saliency map calculated based on similarities between neighboring pixels in an image. Amrutha et al.[1] suggest the best cropping region for image based on region of interest derived from combining Itti's and Standfordmodels.

ii. *Segmentation-Based Approach:*Setlur et al. [15] propose a non-photorealistic method for image scaling. It first assigns saliency values to regions obtained by mean-shift segmentation, by combining saliency map and face detection. Regions of interest are determined from the saliency map and the image is either cropped (if all the objects of interest are contained within the target size) or retargeted (otherwise).This method relies on accurate segmentation of important objects, and generates distortions. However, it has the ability to retain important areas while discarding unimportant background for scenes with two or more scattered regions of interest.

iii. *Seam Carving:*The seam carving technique by AvidanS. et al.[2] is a popular approach for content-aware image resizing. The seam carving approach is to remove some pixels from the image in a judicious manner. The general idea is to decrease the image width (or height) one pixel at a time, by removing a seam of minimal importance. A seam is

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connected path of pixels from top to bottom, or from left to right of the image, depending on which dimension is being reduced that contains only one pixel per row or column.If the importance map is based on gradient energy, the first removed seam will be in a homogeneous area. The image is then readjusted by shifting pixels left or up to compensate for the removedseam, resulting in an image which is one pixel smaller, either on width or height. The image changes only at the seam region, while the other areas remain intact. It produces impressive results when there are enough low-importance seams to be removed, but creates distortions and artifacts when seams cut through important areas.

iv. *Warping-Based Methods:*Warping-based methods, sometimes also referred to as continuous methodsas shown in Fig. 4.It perform nonlinear distortion to obtain the resized image. According to Liu et al. [9, 18] the local distortion of important areas is constrained to be as small as possible, while unimportant regions are allowed to distort more. This way, both important and unimportant areas are kept in the final image, which can be useful for preserving context for the relevant objects. However, depending on the amount of distortion, unimportant areas can even disappear, effectively resulting in content removal. Several methods have been proposed in this category, which make use of different constraints and optimization methods,and can produce smoother resultswhen compared to methods that explicitly remove pixels.

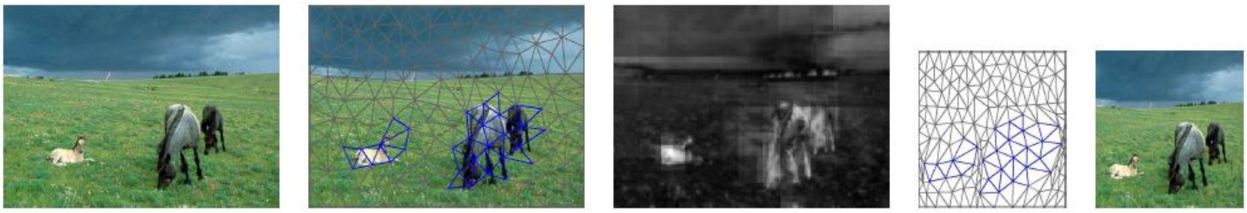

Fig.4.A mesh is built from the input and associated with saliency information.
The mesh is then resized, and the output image is rendered using texture mapping [18].

III. CONCLUSION AND FUTURE WORK

In this paper we have studied different image interpolation techniques like non-adaptive and adaptive techniques. We have also studied that adaptive techniques are better in terms of visual appearance of image but it take more computational time. When time is not constrain then we choose the adaptive technique otherwise non-adaptive techniques are preferable. Based on our application we used either of these interpolation techniques for image scaling. Seam carving is suitable for preserving important areas without any distortion when there are enough low-importance seams to be removed. However, it produces distortions and artifacts when seams cut through important areas. Warping based approaches usually do not create discontinuity artifacts like seam carving does. However, important objects can be distorted, smearing artifacts can appear. In future, we will try analyzed for performance and quality of image interpolation techniques on high-end graphics workstation and parallel computing using adaptive and non-adaptive techniques.

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