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Interpolating Images Towards Near Future: A Survey

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Abstract— In digital image processing when resampling an image or interpolating an image with new coordinates the quality of the image is reduces. To avoid the blurriness or scratches from the image different interpolation techniques are used. The commonly used interpolation techniques are nearest neighbor, bilinear interpolation, bicubic interpolation, B-splines. First technique that is nearest neighbor is simplest and easy to use. It interpolates image only in two steps row wise and column wise. But it works well only with pass band. Second bilinear technique is used to reduce the visual distortion from the image while interpolating. Third bicubic technique is used 16 neighborhood pixels. This technique is better than nearest neighbor and bilinear. Fourth B-splines gives better results in both pass band and stop band. These techniques are used to maintain the image quality when various functions are performed on image to scale up or scale down the image.

Keywords— Digital image, resolution, interpolation, nearest neighbor, bilinear, bicubic, B-splines.

I. INTRODUCTION

Digital Images are made of pixels. These pixels determined the size of the image. Rectangular array represents the pixels. The pixel array is a matrix of M columns and N rows. Width of the image is number of columns and height of the image is the number of rows in the array. Pixels and resolutions are the different things [2]. Pixels consider as the unit of the digital image and resolution depends upon the pixel size. Basically two types of digital images are used commonly:

A. Black and White Images:

In Black and white images each pixel at a particular location holds a single number corresponding to the gray scale [7]. These images are also called binary images or 1-bit images because each pixel is represented by one bit 0 or 1. One represents white color and zero represents black color of the image.

Fig.1 0-255 Gray Scale (0 means black and 255 means white)

B. Color Images:

In color images each pixel of the image holds three numbers corresponding to the RGB (Red, Green, Blue) color model use to measure the intensity and chrominance of light. These are the primary colors.

C. Image Resolution:

Resolution is the number of dots or pixels that make images. Resolution is the detail about the quality of the image that image holds. It depends upon the size of the pixel [5][7]. In digital images density of the pixels describe the resolution. High resolution of the image, contain more information about the image. If we increase the resolution of the image and keep the size same then we get more sharper and detailed image.

1) *Pixel Resolution:* A pixel is a unit of the digital image. The smaller size of the pixel, give high resolution and clearer images. Information within the image depends upon the number of pixels.
2) Spatial Resolution: Spatial Resolution of an image describe as measure of lines that how closely can be resolved in an image.
3) *Spectral Resolution:* The ability to resolve the spectral features and bands of an image into different components.
4) *Temporal Resolution:* In a Remote Sensing System temporal resolution is important. To collect the images of same area of earth's surface at different time periods is the most important feature of remote sensing data.

D. Need of resolution

1) *To Increase the Print Quality:* Images that we download from internet are with low resolution or small sized images. To increase the quality of the image for printing high image resolution is used [4].
2) *To Increase the Frequency of Satellite images:* Satellite images are capture with low frequency and it appears as blurred images [8][15]. Image resolution technique is used to improve the frequency of these types of images.
3) *Improving the Number of pixels:* To represent the detail of an image, resolution techniques are used to improve the number of pixels in the image.
4) *To Refine the Edges of an Image:* When a small sized image is zoomed, resolution techniques are used to refine the edges of the image.

E. Challenges of Image Resolution

It is difficult to improving the quality of satellite images because the frequency is low and images are blurred [1][14]. The edge quality of these images is poor so it is not easy to improve the quality of these images.

II. LITERATURE SURVEY

In [2] had presented Interlacing technique that improved the smoothness of the video without increasing the noise and bandwidth. Various proposed interpolation techniques are used to achieve a high quality interpolation technique. The PSNR value is improved as compared to previous results in this method. This technique provide up to 2db improvement over previous methods.

In [3] has described image scaling algorithm that combines discrete wavelet transform with bicubic interpolation technique. Using simple haar wavelet computation transform gives better results with bicubic interpolation method. The quality and clarity of images is measure with the PSNR values. In this method up to 8db the quality of the image is improved. It reduced the visual distortion in the output image.

In [4] has discussed the comparison of different interpolation techniques. In image domain nearest neighbor has shortest extent that is one interpixel distance. It is good in pass zone instead of stop zone. The linear interpolation technique has extent two interpixels distance and gives good result. The high resolution cubic splines extents over four interpixels distance.

In [5] has introduce a new super resolution technique that used redundant wavelet transform. Redundant wavelet transform does not down sample the image and reduces aliasing effect of the image. This method decompose image into subbands and then interpolated. After this super resolution images are generated using IRWT. The best method is to combine haar wavelet and bicubic interpolation technique.

In [6] has discussed comparison between various interpolation techniques. Nearest neighbor is a simple and easy method to use but does not give effective results. Bilinear interpolation technique gives better results as compare to nearest neighbor. Bicubic causes computational complexity but gives good results so used in 3D images.

In [9] had presented a novel approach to scratches and from contaminated images. It gives more sophisticated images when apply. Proposed kriging interpolation technique implemented with high PSNR value for automatic image inpainting. It gives better output when repainting images.

In [11] has postulated an algorithm to decompose images with a linear kernel function in YUV space that improves the quality of blurred images. This technique is based on linear interpolation kernel. This method boosts on the PSNR value and improve the image quality.

In [13] had introduced nearest neighbor technique for image interpolation. The working detail of the technique defined with examples. Interpolation algorithms and PSNR values described the quality of the image while zooming function applied on the image. Lowpass filter processing technique is applied with the algorithm to interpolate the latter.

In [14] has postulated all the zooming techniques that are interpolation methods with their mathematical functions. Bilinear function performs better than nearest neighbor. Bilinear gives better results. The cubic B-spline is better than linear and nearest neighbor because it has better stop band performance. It provides best combination for both pass band and stop band. The cubic spline algorithm extends over four interpixels distance and linear extends over two interpixels.

In [15] has studied different image enhancement techniques that are adaptive and non-adaptive. Adaptive techniques take more computational time but gives effective results in visual appearance of images. When time is obstacle then non-adaptive techniques are used. These two techniques are combined to overcome the disadvantages of individual methods.

III. INTERPOLATION TECHNIQUES

In image processing various interpolation techniques have been developed and found in literature. Nearest neighbor, linear, splines are most commonly used.

A. Nearest Neighbor Interpolation

Nearest neighbor is the simplest image interpolation technique. This technique is easy to use. It include only two steps are required to perform zooming function. First step is to create new locations for the pixels and second step is assign pixel values to that locations [7][13]. This process is done by creating new rows and columns for images as matrix. This technique is also known as pixel replication. The interpolation kernel for this technique is:

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

Where x = distance between interpolated and grid points.

(a)

(b)

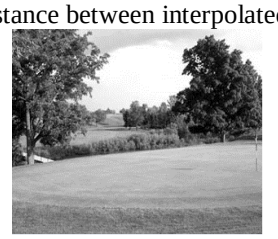
Fig.2 Image (a) is the original image and (b) is zoomed image using nearest neighbor

B. Bilinear interpolation

Nearest neighbor interpolation causes stair case edges so it is not used in high resolution zooming. To overcome this advantage bilinear interpolation technique is used that reduces the visual distortion by fractional zoom computation [10][11]. It uses four nearest pixels to perform function and image is converted into matrix form. This technique is used to perform vertical and horizontal both directions. The interpolation kernel for this method is:

$$u(x)=\begin{cases} 0 & |x|>1 \\ 1-|x| & |x|<1 \end{cases} \quad (2)$$

Where x = distance between interpolated and grid points.



(a)

(b)

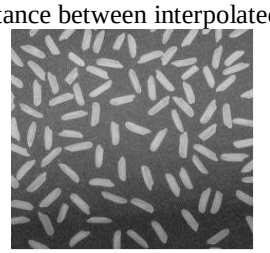
Fig.3 Image (a) is the original image and (b) is zoomed image using bilinear interpolation

C. Bi-cubic interpolation

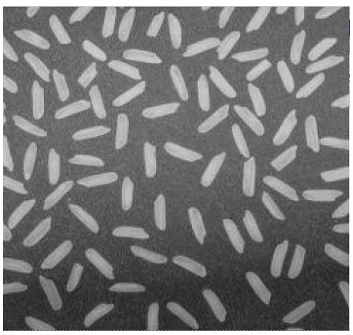
Bicubic interpolation is best technique as compare to the previous techniques. It uses 16 neighborhood pixels to calculate final results [3]. These pixels are locate at different distance and nearest pixels are given higher weighting in the final calculation [9][12]. This technique give better results than the previous two techniques but take more conceptual time. The interpolation kernel for this method is:

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

Where x = distance between interpolated and grid points.



(a)



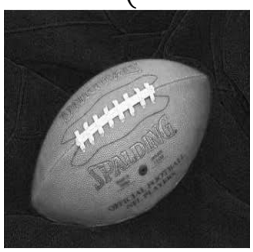
(b)

Fig.4 Image (a) is the original image and (b) is zoomed image using bicubic interpolation

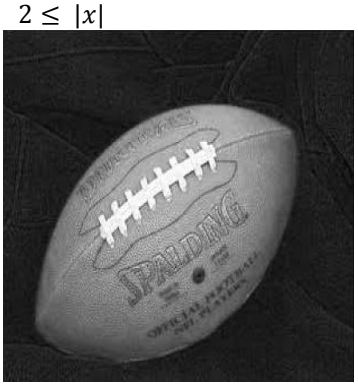
D. B-splines Interpolation

Basis spline (B-spline) interpolation technique has better performance response in both pass band and stop band [4]. Polynomial pieces that are connected together to perform computation are called splines [6]. These splines can be derived from different self-convolutions functions. The kernel for this technique is:

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



(a)



(b)

Fig.5 Image (a) is the original image and (b) is zoomed image using B-splines

IV. CONCLUSIONS

Different interpolation techniques are discussed in this paper with their mathematical functions and visual appearance of images. These techniques are used to perform the zooming function. Nearest neighbor performs well in pass band but not in stop band. Bilinear interpolation technique give better results in both pass band and stop band. Bicubic uses 16 neighborhood pixels to perform the zooming function. When time is not considered as important factor this technique is best suitable as compare to other techniques. B-splines technique gives better result and smooth output image but computation is complex in this technique. These techniques are also used to remove the distortion from the image and make a sharper image.

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