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Review of Different Schemes for Image Enlargement

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Abstract: In the development of modern information technology, image processing is becoming more and more important in our life. Digital zooming is encountered in many real applications such as electronic publishing ,image data base ,digital camera ,visible wireless telephone ,medical imaging, remote sensing and so on.In order to have better and fine images for users ,images are need to be reproduced to higher resolution from lower resolution. Image enlargement is done through interpolation technique which introduces many artifacts. Here new method is introduced for image zooming which is combination of conventional bilinear interpolation and error amender technique called EASE.
Index Terms: Interpolation, Error Amender Sharp Edge detection (EASE), Mean Square Error (MSE), Signal to Noise Ratio (SNR), Root Mean Square Error (RMS)

I. INTRODUCTION

Digital images are the most common and convenient means of conveying or transmitting information. They convey information about positions, sizes and inter-relationships between objects. Image enlargement or zooming is important in many aspects of today's digital world. Image enlargement is among the fundamental image processing operations. Typically zooming is related to scaling up visuals or images to be able to see more detail, increasing resolution, using optics, printing techniques, or digital processing. In all cases, the zooming of the image does not change the perspective of the image.

Applications are varied in different fields. In medical imaging, zooming can serve to improve the chances of diagnosing problems by highlighting any possible aberrations. Enhancing image details can also be useful for the purposes of identification, whether for improving the quality of an image interpreted by a biometric recognition system or trying to get a clearer view of the perpetrator of some crime. In entertainment, zooming can be used to resize a video frame to fit the field of view of a projection device, which may help to reduce blurring. Finally, the most obvious application of image zooming is to simply allow one to enjoy a larger version of a favourite image obtained from any commercially available digital imaging device such as a camera, camcorder or scanner.

For instance, high-resolution cameras are able to digitize scenes at a much finer scale and thus capture much more detail than lower-resolution cameras. Unfortunately, not all pictures and images can be stored at high resolution due to equipment, memory, and in the case of the Internet, bandwidth limitations. Consumers still need low-resolution images to be enlarged to higher resolution for viewing, printing, and editing, creating a need for interpolation algorithms that give end-users these magnified images.

Image interpolation is a process that estimates a set of unknown pixels from a set of known pixels in an image. It has been widely used in a variety of applications such as image resizing, image zooming, image enhancement, image reduction, sub pixel image registration, image decomposition and to correct spatial distortions and many more.

Many of the interpolation techniques like nearest neighbor, bicubic, bilinear and new edge directed interpolation [1] are available, which are discussed in section II. These techniques show many artifacts such as jaggies, blur, checker board effect and many more which are discussed in section III. Here we have proposed technique which will take digital image and enlargement factor as input and gives enlarged image with sharpened edges as image enlargement using error amender technique. This is discussed in section IV.

II. INTERPOLATION

Interpolation is the process of defining a spatially continuous image from a set of discrete samples. Many of the interpolation techniques like nearest neighbor, bicubic, bilinear are available in many image processing tools like Photoshop. Various applications of interpolation are image resizing, image zooming, image enhancement, image reduction, sub pixel image registration, image decomposition and to correct spatial distortions and many more.

Below figure shows the effect of interpolation on an image

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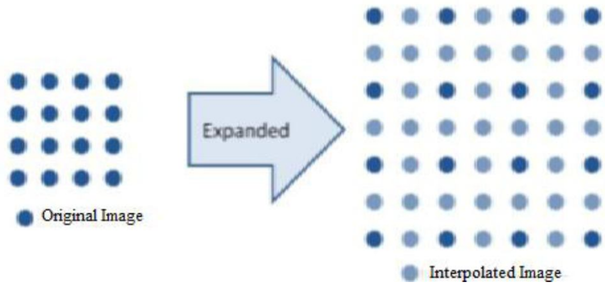

Fig1. Interpolation technique

Interpolation techniques are mainly divided in two categories:

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. 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.

1) *Nearest Neighbor Interpolation*: It is the most basic interpolation technique and requires less processing time among all the interpolation techniques. In this technique the interpolated pixel is replaced by the nearest pixel. Nearest neighbor interpolation is a simple method of linear interpolation. It is easy to implement. It gives good result when the image has high resolution pixels. In this some information at the edges is lost.

The interpolation kernel for nearest neighbor interpolation [2] is:

u (x) = { 0 |x| > 0.5
{1 |x| < 0.5

Where x = distance between interpolated point and grid point.

2) *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 [3]. 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.

u(x) = { 0 |x| > 1
{1 – |x| |x| < 1
Where x = distance between interpolated point and grid point.

3) *Bicubic Interpolation:* Bicubic interpolation is best among all non-adaptive techniques. Bicubic interpolation takes a weighted average of the 16 pixels to calculate its final interpolated value. These pixels are at various distances from the unknown pixel. Closer pixels are given a higher weighting in the calculation [3]. Bicubic gives sharper images than previous two methods. This technique gives better result but take more computational time. When time is not a constraint then this technique give the best result among all the non-adaptive techniques.

The interpolation kernel for bicubic interpolation is [3]:
{3/2|x|3 – 5/2|x|2 + 1 0<=|x| < 1
u(x) = {-1/2|x|3 + 5/2|x|2 – 4|x| + 2 1<= |x|<2
{0 2 < |x|
Where x = distance between interpolated point and grid point.

B. Adaptive technique

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. Various adaptive techniques are NEDI, DDT and many more.

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1) *New Edge-Directed Interpolation:* NEDI technique is a combined approach of bilinear interpolation and covariance based adaptive interpolation. In linear interpolation techniques have blurred edges and artifacts. Mainly two purposes to introduce NEDI technique: first is to produce better visual quality then linear interpolation techniques (Bilinear and Bicubic) and second is to reduce the computational complexity of covariance based adaptive interpolation technique [1].
2) *Data Dependent Triangulation:* Data dependent triangulation interpolation technique is developed to improve the visual quality of image and to reduce the computational complexity of image with respect to other linear interpolation techniques. DDT is mainly used to overcome the disadvantages of bilinear interpolation technique. DDT gives better result than bilinear interpolation in term of visual appearance and has low computational complexity. DDT is better than other interpolation technique like NEDI, Edge Guided interpolation for these following reasons:

a) DDT is as simple as bilinear interpolation technique while the other techniques are complex.
b) DDT can be used in arbitrary enhancement, arbitrary scaling while other techniques are defined for magnifying [4].

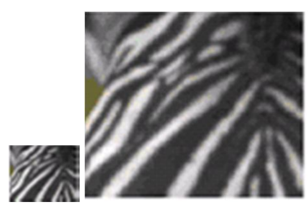
III. ARTIFACTS CAUSED BY INTERPOLATION

Interpolation is the process of determining the values of a function at positions lying between its samples. It achieves this process by fitting a continuous function through the discrete input samples. This permits input values to be evaluated at arbitrary positions in the input, not just those defined at the sample points. Interpolation reconstructs the signal lost in the sampling process by smoothing the data samples with an interpolation function. The process of interpolation is one of the fundamental operations in image processing. The image quality highly depends on the used interpolation technique. Image resolution, or the appearance of resolution, is important in many aspects of today's digital world. For instance, high-resolution cameras are able to digitize scenes at a much finer scale and thus capture much more detail than lower-resolution cameras.

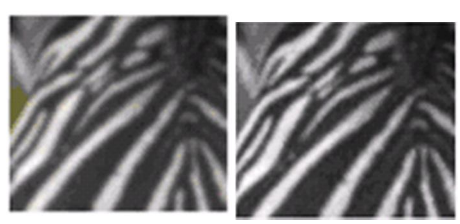
Interpolation introduces artefact's in enlarged image some of them are described in details as follows:

The above image is magnified and three types of major artifacts are compared.

1) *Jagging:* Blocks are formed due to replication of pixels
2) *Blurring:* It is un-clarity of the image
3) *Ghosting:* It is the distortion of the image.



(a) (b) jaggies



(c)blurries(d) ghosting

Fig 2. Zebra Image[6]

Original

Fig 2 Aliasing effect[6]

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A. Aliasing

It is a process in which high frequency components of a continuous function masquerade as lower frequencies in the sampled function.

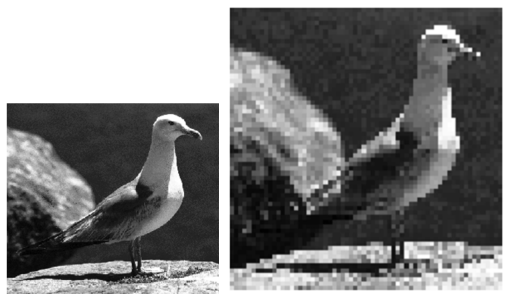
Spatial aliasing is caused by under-sampling a function, while temporal aliasing is related to time intervals between images in a sequence of images. The key concern, with spatial aliasing in images are the introduction of artifacts such as jaggedness in line features, spurious highlights, and the appearance of frequency patterns not present in the original image.

B. The Checkerboard Effect

This effect is observed by leaving unchanged the number of grey levels and varying the spatial resolution while keeping the display area unchanged. The checkerboard effect is caused by pixel replication, that is, lower resolution images were duplicated in order to fill the display area. The Checkerboard effect creates a checkerboard pattern of rectangles, half of which are transparent. This phenomenon can be visualized in the images shown in Fig. 3

C. Gaussian Blur

It is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen, distinctly different from the bokeh effect produced by an out-of-focus lens or the shadow of an object under usual illumination.



Original Checkerboard effect

Fig 3. Checkerboard effect[5]

Original Image Blurred image

Fig 4. Gaussian Blur[6]

IV. PROPOSED ALGORITHM

Traditional interpolation technique has many drawback or artifacts as seen section III, hence new technique called Error Amended Sharp Edge detection technique (EASE)[4] for Enlargement of digital image is discussed here. Basic idea of this technique is based on bilinear method of interpolation. It tries to amend error by utilizing the interpolation theorem in edge adaptive way.

Image Enlargement is to expand the original (n x n) image to (2n-1) x (2n-1). In the below figure the X (5 x 5) is the original image and Y (9 x 9) is the magnified image. X(i,j) is the pixel in the original image where i is the ith row and j is the jth column. In the same way in Y(m,n), m is the mth row and n is the nth.

The black dots represent the pixels in the original image (X). And those pixels are as it is copied in the image Y. These pixels can be mapped as:

$$X(i , j) = Y(2i-1 , 2j-1) \qquad (2)$$

The white dots represent the unknown pixels whose values have to find. When an image is magnified 2 times, total number of pixels will be four times. Hence, now we have 1 known and 3 unknown pixels and have to find 3 other with bilinear algorithm.

Logic of this technique for 1D is first find out interpolation of 1D signal then calculate error in interpolation called error amender. Error amender is ideally the vertical distance connecting the two points.

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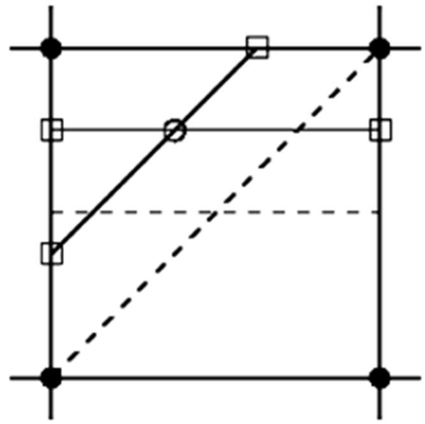

Fig. 5 EASE technique for an interior point [5]

Consider, resampling evaluation requires at most 12 pixels of the low resolution image for the estimation of the edge orientation and at most seven pixel values for the resampling.

EASE technique [4] for edge enhancement is applied. Firstly need to find out edges in image. This is done by checking sharp intensity difference in neighbour pixels.

A. Flow of Proposed Algorithm

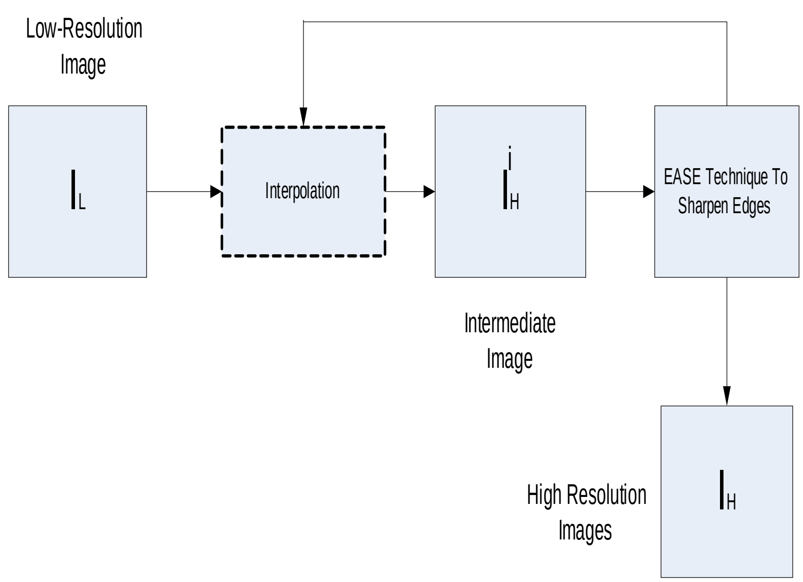

Fig 6. Flow of low resolution image to get enlarged to desire

Enlargement factor

I_L = low resolution image

I_H = high resolution image

I^i_H= intermediate image

The input image is firstly interpolated using bilinear interpolation technique which may include interpolation artifacts hence it goes through EASE technique to sharpen edges. This is repeated up to desired enlargement factor is achieved.

The Fig. 7 shows complete system and its modules such as Input section, processing/implementation section and analysis section. The detailed explanation is as follows.

1) *Input Section:* This section will contain many types of real world images from different imageries such satellite images, medical images such as CT scan images, cartoon images and digital camera captured images.
2) *Processing/Implementation Section:* Image from imageries will be supplied as input to Bilinear, Bicubic and EASE methods.

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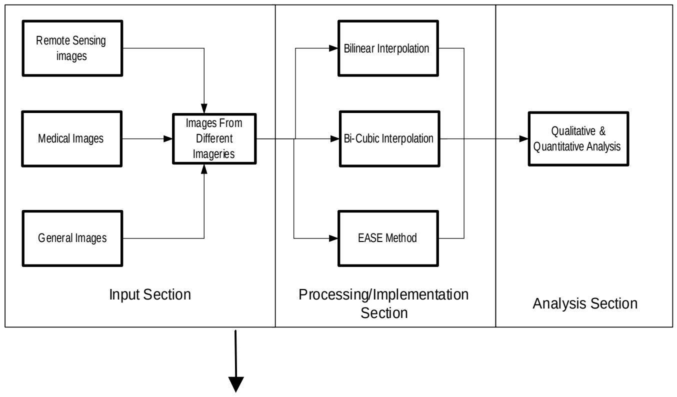

Method	Image Processing Metric		
	SNR	RMS	MSE
Bilinear Interpolation			
Bi-Cubic Interpolation			
EASE Method			

Fig 7 System block diagram

3) Analysis section:-In this section Qualitative and Quantitative analysis will be done. It will contain Visual Comparison, Human user study, Qualitative analysis and Accuracy measurement by calculating SNR, RMS and MSE.

V. CONCLUSION

An image enlargement approach has been proposedin this paper. The proposed approach utilizessobel edge detection to find error amender. This proposed algorithm greatly reduces interpolation artifacts.

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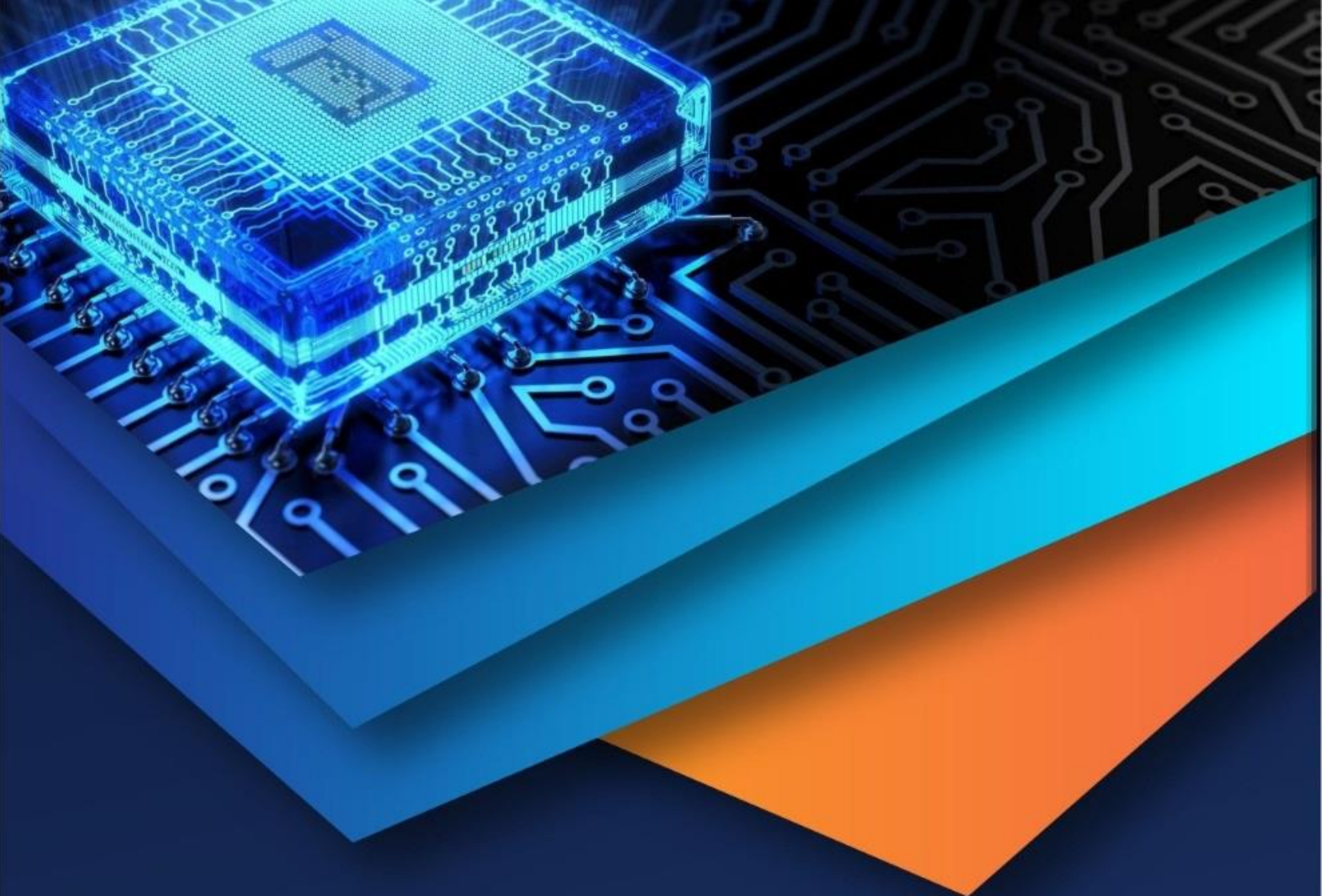

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