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RESEARCH ARTICLE

PERFORMANCE ANALYSIS OF IMAGE INTERPOLATION TECHNIQUES

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ABSTRACT

Image Interpolation is an oversampling operation used in various applications. Simple interpolation techniques nearest neighbour, bilinear and bicubical produce edge blurring, jagging etc in the interpolated image. To understand the characteristics of image interpolation, study of various techniques is needed. In this paper, the performance of various image interpolation techniques is compared by evaluating the quality metrics like PSNR, MSE and Runtime. This comparison provides the use of different methods and also helpful for implementing the new interpolation methods.

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INTRODUCTION

Digital Image is a discrete representation of its continuous counterpart perceived through our eyes, a camera or any such devices. Its representation and processing in computer requires to stored it in digital format. Sampling the image for computer storage often degrades its visual representation in a variety of display units. So the image needs further processing to suit our demands. Image interpolation is one such image processing task to find the values of the pixels of the image which are not originally present in the image. It finds application in medical image processing like X-ray imaging, representation of multimedia content in web, satellite images processing for weather forecasting, industrial inspection for defective manufactured parts which requires image resizing, high resolution. In this technological endeavour several interpolation techniques have been developed ranging from very simple to highly complex techniques. Image interpolation become the preprocessing step for other image processing tasks like image registrations, image rotation. Image registration needs interpolation to accurately register the image at subpixel level.

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Basic Image Interpolation Methods

The basic image interpolation methods are Nearest neighbour, Bilinear and bicubical interpolation methods. Nearest neighbour interpolation is the simplest interpolation technique in which the unknown pixel intensity is selected from the nearest pixel to it. It has very less computational cost because of its simple calculation. The frequency domain response of nearest neighbour interpolation technique is very poor since it has dominant sidelobes. Bilinear interpolation is an extension of bilinear interpolation in which the unknown pixel intensity is obtained from four neighbour pixel intensities and the output image is smoother than Nearestneighbour. The frequency domain response of bilinear interpolation technique is better than nearest neighbour interpolation since it has less dominant sidelobes. In the Bicubical Interpolation, the unknown pixel intensity is obtained from eight neighbour pixel intensities. When compared these three techniques, the output image is smoother and frequency domain response is better than nearest neighbour and bilinear techniques. Inaddition to the above basic techniques, Jian Zhang *et al*. (2009) proposed Fast and Effective Interpolation method Using Median Filter (FEIMF) uses non linear iterative procedure which produces images with good visual quality and lower computational complexity. Jiang Tao *et al*. (2010) developed a new interpolation method using newton forward difference method which produces better interpolated image compared to basic methods. Xin Li *et al*. (2001) proposed a new edge-directed interpolation (NEDI) that

uses the geometric duality between low-resolution covariance and high-resolution covariance of image which groups the pixels along the same direction. Nicola Asuni, Andrea Giachetti proposed an improved NEDI (Asuni *et al*., 2008) by non-edge pixel handling, window shape, edge segmentation, value adjust and matrix conditioning, error propagation and minimum norm solution. W.S. Tam, C.W. Kok and W.C Siu in, proposed Modified Edge-directed Interpolation (Am *et al*., 2010) which adopted a training window structure to eliminate interpolation error propagation problem and extended the covariance matching into multiple directions to suppress the covariance mismatch problem. Zhenhua Mai, Jeny Rajan, Marleen Verhoye, Jan Sijbers proposed Robust NEDI(R-NEDI) (Zhenhua Mai *et al*., 2011) which improves the least square nature of NEDI by non local mean(NLM). Non-local means(NLM) for denoising (Gonzalez and Woods, 2008) which is able to differentiate between non-local neighborhood patterns from noiseless pixel values based on similarity of their corresponding neighbourhoods.

Performance Analysis

The performance of various interpolation methods is compared by evaluating Peak Signal to noise ratio (PSNR), Mean Square Error (MSE) and Run time. The performance metric, mean square error (MSE) is defined as

$$\text{MSE}=\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}(I(i,j)-K(i,j))^2 \quad (1)$$

Where m and n are number of rows and columns of the image and I(i,j) and K (i, j) are reference and Interpolated images respectively.

The peak signal to noise ratio is defined as

$$\text{PSNR}=10*\log_{10}\frac{mn}{MSE} \quad (2)$$

In addition to the above parameters, the run time for the Interpolation algorithm is calculated by using tic and toc commands in the MATLAB.

RESULTS

All the interpolation algorithms are implemented in MATLAB on different images and performance metrics are calculated for each algorithm. The different images considered are Lena, Cameraman and Barbara. Initially each image is resized to 256*256 and it is interpolated by a factor of 2 to get the original image. Finally median filter is applied on all interpolated images to preserve the edges.

Figure 1 obtained after resizing the 512*512 image into 256*256. Now it is zoomed back to 512*512 by using various image interpolation techniques and then filtered by using median filter. The results are shown in Figure.2 to Figure.6.

Comparison of Results

In this section, the performance metrics are compared for each algorithm and for different images and are plotted. The below table-1 shows the Mean square error obtained for Lena, Cameraman and Barbara images by a factor of two using various image interpolation methods.

Figure 1. Image to be Interpolated

Figure 2. Interpolated by Nearest neighbour Technique

Figure 3. Interpolated by Bilinear Technique

Figure 4. Interpolated by Bilcubical Technique

Figure 5. Interpolated by FEIMF Technique

Figure 6. Interpolated by Newton Forward Technique

Table 1. Mean Square Error

MSE			
Interpolation Technique	*Lena*	*Cameraman*	*Barbara*
Nearest Neighbour	42.47	10.75	43.17
Bilinear	39.12	10.45	40.14
Bi cubic	19.72	10.53	42.46
FEIMF	30.93	12.48	45.26
NFD	3.11	3.95	7.5

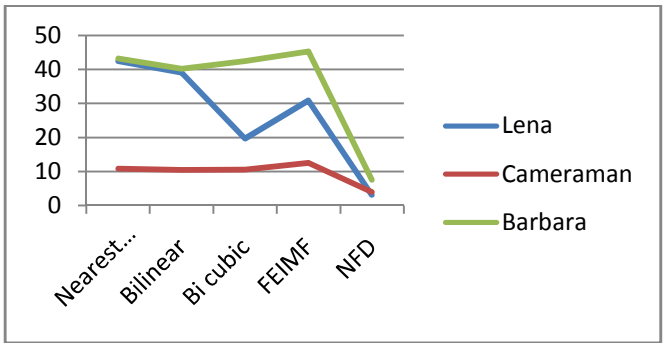

Figure 7. MSE Plot for various Images

From the above Figure 7, Newton forward interpolation has less error when compared with other techniques because it gives known pixel intensity by considering number of neighbouring pixel intensities with different weights.

The below Table-2 shows the Peak Signal to Noise Ratio obtained for Lena, Cameraman and Barbara images by a factor of two using various image interpolation methods.

Table 2. Peak Signal to Noise Ratio

MSE			
Interpolation Technique	*Lena*	*Cameraman*	*Barbara*
Nearest Neighbour	37.92	43.87	37.83
Bilinear	38.26	43.99	38.14
Bi cubic	41.24	43.95	37.9
FEIMF	39.28	43.21	37.63
NFD	49.25	48.21	45.34

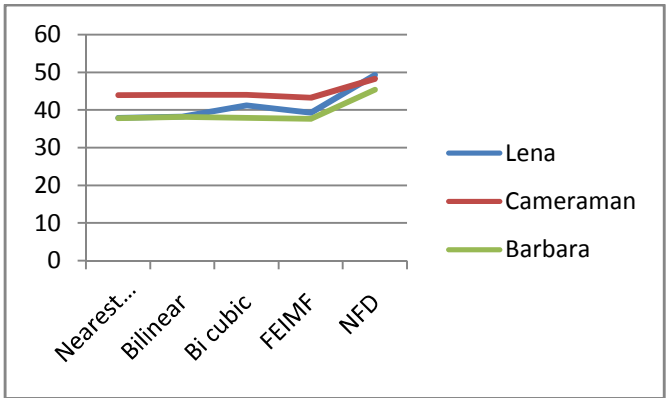

Figure 8. PSNR Plot for various Images

From the Figure 8, higher PSNR is obtained by using Newton forward interpolation method.

The below Table-3 shows run time for Lena, Cameraman and Barbara images by a factor of two using various image interpolation methods.

Table 3. Run time

RUNTIME(in sec)			
Interpolation Technique	*Lena*	*Cameraman*	*Barbara*
Nearest Neighbour	3.41	3.324	3.42
Bilinear	6.83	6.864	6.74
Bi cubic	4.62	4.702	4.68
FEIMF	2.33	1.96	1.99
NFD	3.62	3.47	3.52

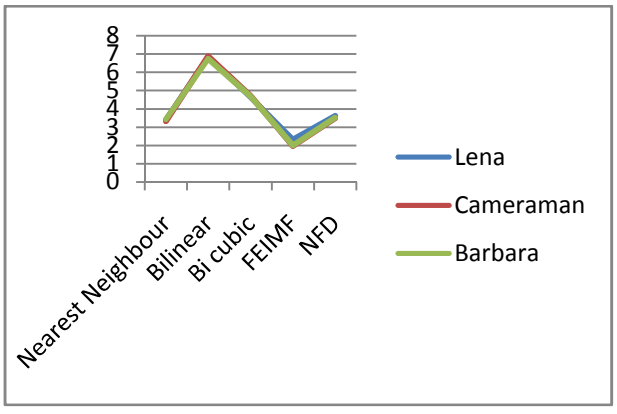

Figure 9. Runtime for various Interpolation methods

From the Table 3, Fast and Effective Interpolation method Using Median Filter has less execution time than other interpolation methods

Conclusion

In this paper, various interpolation techniques are implemented on three different images and filtering technique is also

implemented to remove unnecessary patterns. From the results, Newton forward image interpolation technique performs better than Existing classical methods which are having little more computational cost. But Newton forward image interpolation technique needs higher runtime.

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