Scaling of Digital Image using Pixel Replication

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Abstract:

Image Interpolation is a basic part to scale the advanced image. The proposed interpolation technique used the back propagation algorithm for picture scaling and zooming. The back propagation algorithm learns from the current pixels and generates the new location of pixels. It calculates the error where error is the difference between actual output and desired output. The pixel that has least error is replicated first. The proposed method is evaluated using image quality metrix (IQM) like Peak Signal Noise Ratio (PSNR), Mean Square Error (MSE), Signal Noise Ratio (SNR) and Structure Similarity index (SSIM) of scaled image. From experimental result with scaling factor of 1, it has been concluded that the proposed method reduced the complexity 74.96% of an image as compared Gradient Based method reduced complexity of an image is 76.97%. So, proposed method defines better result as compare to Gradient Based method.

Keywords— Nearest Neighbor Interpolation, Bilinear Interpolation, Gradient Based Method, Scaling.

Introduction

Image scaling [1] is pertaining to resize of digital image. To resample the image suggests that zooming or stretching the image. Image scaling is one in every of the essential desires that are ordinarily utilized in pictures with exploitation completely different techniques for their smart quality. There are numerous applications that require the technique of image scaling such as medical images, digital shadowgraph, printing, computer vision, remote sensing. There are two forms of picture processing: analog image and digital image. Analog pictures are two-dimensional pictures within the sort of analog and check with a signal. Remote detector is that the model of associate analog image. Digital pictures are also two dimensional pictures represent into a binary kind. Preliminary to resize the image from low resolution to high is that the main motive of interpolation technique [2, 3, and 4]. Image interpolation is additionally delineated into two categories: reconciling and Non-Adaptive. In Reconciling formula of process logic is rely depend upon the feature of image and contents of a picture whereas non-adaptive, process logic is fixed regardless of input picture features element [5]. There is completely different technique to resize the picture by pixel replication such as nearest neighbor interpolation method, bilinear interpolation method, and gradient based method and so on. After scaling, resizing and stretching of a picture, the quality of an image depends upon the sort of misinterpretation and reduction forced on interpolated image consistent with information of creative image.

Related Work

Image interpolation is a vital part of digital picture. The main motive of using interpolation method is scaling the image for good result. There are variety of ways are used for scaling of a picture. Image zooming and stretching is an essential part of digital image by using different interpolation methods. There are some

standard victimization image scaled strategies are associated with planned work. As below also discuss their benefits and disadvantages:

a. Nearest Neighbour Interpolation Method

Nearest neighbor interpolation is that the simplest method that replicates the pixels with the neighbor pixels at scaling ratio 0.2505. Advantage of nearest neighbor is easy to use and quick processing method. It makes the image too blockish is a disadvantage of nearest neighbor interpolation methodology [2]. The mathematical expression for nearest neighbor interpolation shown as following:

$$G(m) = \begin{cases} 1 & 0 \le |m| < 0.5 \\ 0 & 0.5 \le |m| \end{cases} \quad (1)$$

Where m is distance between grid and interpolated point.

b. Bilinear Interpolation method

Bilinear interpolation method is window preliminary based method. It calculates the pixel value in each direction: horizontal and vertical at scaling ratio 0.2505. Bilinear interpolation provides smoothness result and fairly low procedure quality. The ensuring image is fuzzy [2, 3, 4, 6] in bilinear interpolation method. Mathematical expression of bilinear interpolation is show as following: Let bilinear interpolation method is to seek the value of the unknown perform *f* at the purpose (*m*, *n*). And assumed that the value of *f* at the four points *Z*11 = (*m*1, *n*1), *Z*12 = (*m*1, *n*2), *Z*21 = (*m*2, *n*1), and *Z*22 = (*m*2, *n*2). Foremost we have to outline the linear interpolation in the *x*-direction. The equation becomes:

$$f(m, n1) \approx \frac{m_2 - m}{m_2 - m_1} f(Z_{11}) + \frac{m - m}{m_2 - m_1} f(Z_{21}) \quad (2)$$

$$f(m, n2) \approx \frac{m_2 - m}{m_2 - m_1} f(Z_{12}) + \frac{m - m_1}{m_2 - m_1} f(Z_{22}) \quad (3)$$

After interpolate in x-direction, interpolation of pixels in the y-direction and equation becomes:

$$f(m, n) \approx \frac{n_2 - n}{n_2 - n_1} f(m, n_1) + \frac{n - n_1}{n_2 - n_1} f(m, n_2) \quad (4)$$

c. Gradient based method

Inclination based technique [1, 7] depends on two stages: correct pixel duplicate and multistage slope. At scaling proportion 1 right off the bat slope based technique recreate the correct pixel, furthermore multistage angle based plan the picture work utilizing N4 bearing at that point filling remaining pixels utilizing n8 headings. Favorable position of slope based is diminished the multifaceted nature of computerized picture.

d. Cubic Convolution Interpolation Method

Cubic convolution insertion strategy (CC) is likewise utilized for zooming or extending the advanced picture [8, 9]. Cubic convolution strategy interjects the picture in even, vertical heading and furthermore introduces the picture corner to corner insightful for better consequence of zoomed or scaled picture. It played

out the all the more effectively result, superior to closest neighbor and bilinear interjection strategy. Cubic convolution technique is less productive than cubic spline strategy. The numerical articulation of cubic convolution strategy is as per the following:

$$G(m) = \sum_k c_{k^u\left(\frac{m-m_k}{h}\right)} \qquad (5)$$

Proposed Interpolation Method

The back proliferation calculation is utilized as a part of proposed technique which is a standout amongst the most helpful calculations of neural system. The proposed addition technique for picture scaling prompts increment the precision of zooming and extending of a picture with scaling proportion 1and reduced the complexity of a picture. Back proliferation calculation is connected to reproduce the pixels and just that pixels are recreate which has least error where error is the difference between actual output and desired output layer. Firstly back proliferation calculation finds the weight of hidden layers in proficient way that the result may out with least or minimum error. After computation of error, the back proliferation calculation must be updating the weight of pixels. For executing of back propagation algorithm, there are four steps to executing back propagation algorithm:

- Feed-Forward Computation.
- Back Propagation to the Yield layer.
- Back spread to the shrouded layer.
- Weight update.

For executing of back engendering calculation, these means are disclosed as following to executing back spread calculation:

- Feed-Forward Computation: In bolster forward calculation inputs are created into forward heading and data sources are put away in each yield unit.
- Back Propagation to the yield layer: The sources of info are forward to yield layer and system is hurry to back direction from yield to input.
- Back spread to the shrouded layer: In this progression concealed layer inputs are associated with the contributions of yield layer and last outcome back pedals to shrouded layer.
- Weight update: The information weights are refreshed in negative inclination course. It is critical to give the weight to inputs since error is finding to check the weights of information sources. The contribution of systems has most reduced weight than that info is recreated first.

At the time, value of error function is small then algorithm is stopped. Mathematic expression for back propagation algorithm is:

$$\text{Actual Output: } \sum_{\substack{w=0 \\ x=0}}^{\substack{w=n \\ x=n}} x_n w_n + bias \qquad (6)$$

Where x is the pixel number of an image, w1 is the pixel intensity.

For error calculating:

$$\text{Error= Desired output- Actual Output} \qquad (7)$$

Error is calculated for finding the least error in an image. On which place the least error is occurred then that pixel is replicated for scaling and zooming of digital image. The bias term also act as weights.

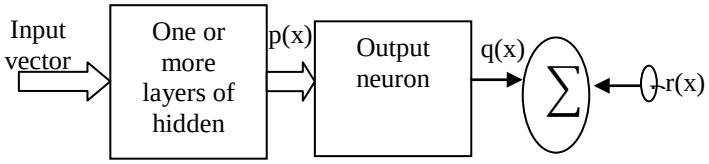

Figure 1. Block Diagram of Neural Network used in the Proposed Method.

Architecture of Back propagation Neural Network

The information sources are sent to the Back engendering system (BPN) and the yield acquired from the net could be either paired frame (0, 1) or bipolar (- 1, +1). Amid the back-proliferation period of learning, signals are sent in the switch course.

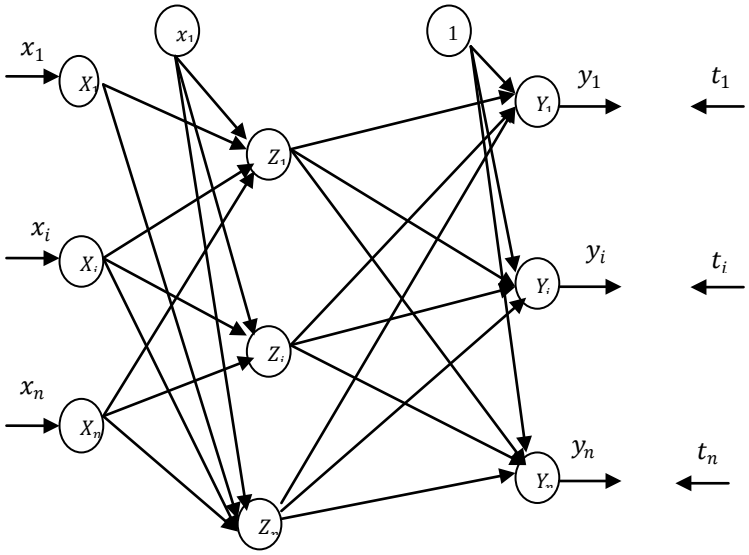

Figure 2. Architecture of Back Propagation in Neural Network

Steps for Proposed Method

Step1. Input the image which needs to be scale and also gave scaling factor between 0 and 1.

Step2. Scale the image by applying pixel replication technique.

Step3. Select the replicated pixels.

Step4. If pixel is selected then calculate actual output using equation (6).

Step5. Error is calculated from difference between desired output and actual output.

Step6. Pixel which has minimum error is selected as best pixel for the replication. To find the best pixel, repeat the steps 3 to 5. And find the minimum error.

Step7. Replicate the pixels which are selected and for the replication to scale image.

a. Flowchart for Proposed Interpolation Method

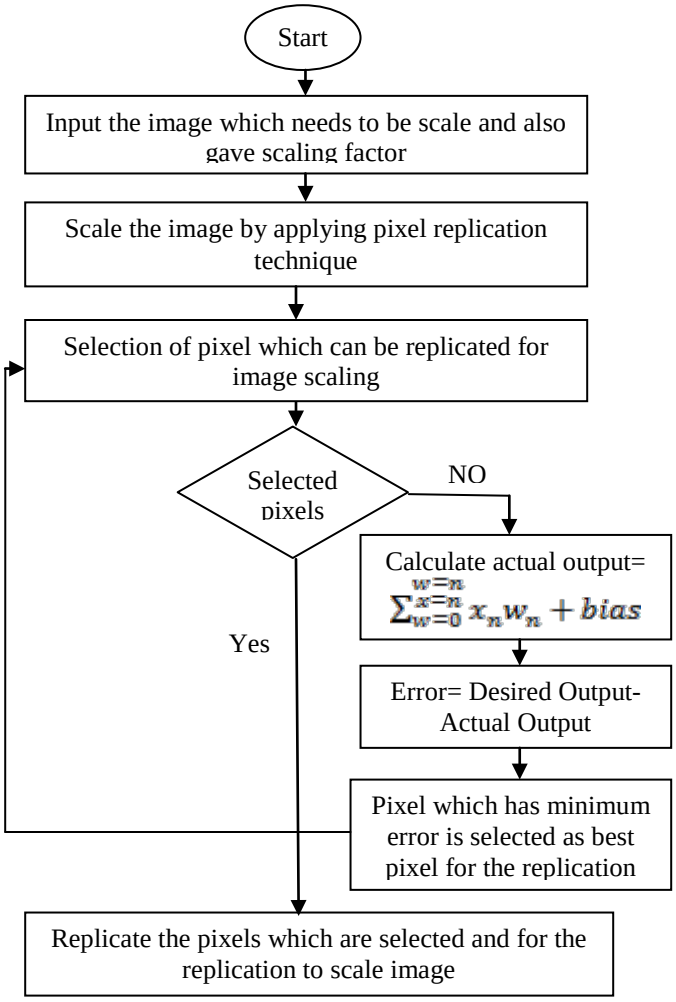

Figure 3. Flow Diagram for the Proposed Interpolation Method.

Pseudo Code of Proposed Algorithm

```
Input: Image which need to scale
Output: Scaled Image
        For i=1:number of rows
                For j=1:number of columns
Calculate (scaling factors )
If (A(i,j) >A(i+1,j+1))
        Scale (A(i,j))
Else
        Scale (A(i+1,j+1))
Apply back propagation for pixel replication
        For i=1: number of rows
        For j=1: number of columns
 Calculate actual output ()
 Actual Output: ∑_{w=0}^{w=n} ∑_{x=0}^{x=n} x_n w_n + bias
 Calculate error ()
        Error = Desired Output − Actual Output
 If (error (i, j) <error (i+1, j+1))
        Replicate pixel (i, j)
 Else
        Replicate pixel (i+1,j+1)
        End
        End
 End
```

In the proposed algorithm, back propagation is used for workout the exaggerated neural networks and besides utilizes one and the other phase cycle which involves the propagation and weight updates. When an input incorporate enters the consolidate, it is propagated forward on the consolidate across each layer until it reaches the yield layer. The comparisons are made by the produce achieved as well as the desired output. This is done utilizing a ceasing to exist function. For a throw neuron in the output layer, an error value is calculated. The propagation of the error values is then done in backward method which starts from the output. Here, each neuron has it's seize error value which also shows its contribution to the virtually achieved output.

Result and Discussion

In this section results of the proposed method is presented and discussed. In the proposed work Back Proliferation Algorithm is used for the better effects of zooming and scaling of an image by using scaling ratio 1. The proposed technique has been done in MATLAB 2012a. The proposed work has been tested on four images that are Lena Image, Aeroplane Image, Flower Image and Parrot Image and compare the performance of proposed work with Nearest Neighbor Method, Bilinear Method and Gradient Based Method.

The result has been shown only on Lena image. Not all the images result has been shown because of the shortage of space in research paper. Different interpolation results has been shown in Figure 4 (a) shows the original image of Lena. (b) Shows the result of zoomed Nearest Neighbor Method (NN) and produced blocky image. (c) Shows the result of zoomed Bilinear Method (BL) and image should fairly blurred. (d) Shows the result of zoomed Gradient Based Method (GB) and shows the maximum complexity of an image. (e) Shows

the result of zoomed Proposed Method and reduced the complexity of an image with ratio 74.96%. From experimental results it has been concluded that the proposed method is better than Gradient Based Method. From experimental results, also discuss the Peak Signal Noise Ratio (PSNR) of an image is low as compare to Mean Square Error (MSE) and Signal Noise Ratio (SNR).Graphical result of proposed work are as following:

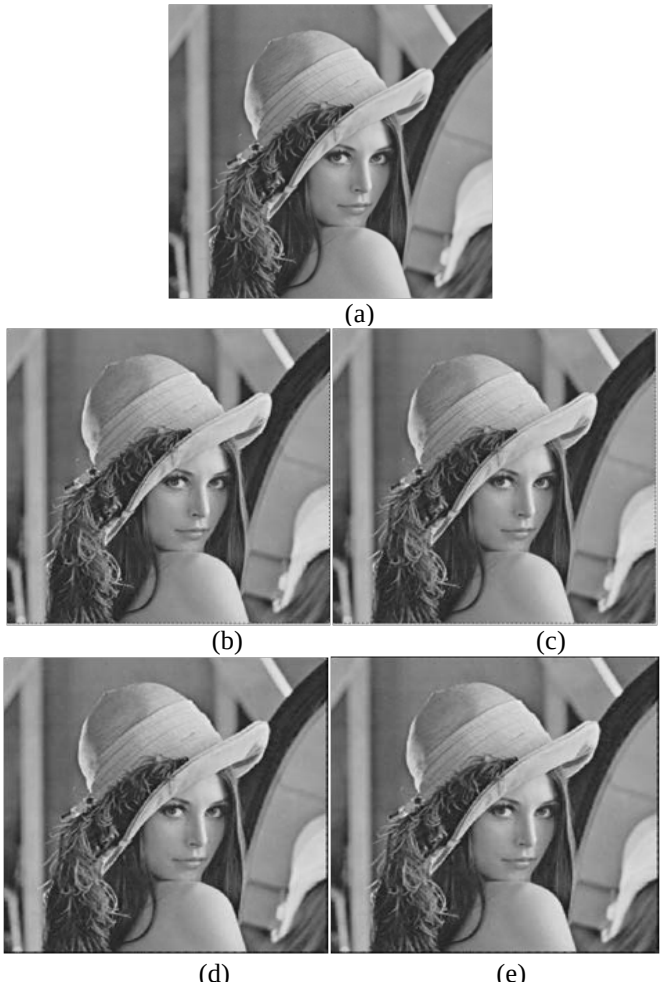

Figure 4. Interpolation results for Lena image. (a) Original image. (b) Zoomed image by using Nearest Neighbor (NN) Method. (c) Zoomed image by using Bilinear (BL) Method. (d) Zoomed image by using Gradient Based (GB) Method. (e) Zoomed image by using proposed interpolation Method

Performance Parameter

There are four types of parameters are used: Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Signal Noise Ratio (SNR), Structure Similarity index (SSIM).

Peak Signal to Noise Ratio

It is the estimation of peak blunder between the Zoomed picture and unique picture, equation is given as:

$$\text{PSNR} = 10\log_{10}\left(\frac{255^2}{\text{MSE}}\right) \qquad (8)$$

Signal Noise Ratio

It is characterized as the proportion of the power flag (significant data) and the energy of foundation clamor (undesirable flag), equation is:

$$SNR = \frac{\mathbf{P}\text{signal}}{\mathbf{P}\text{power}} \qquad (9)$$

P is the average power.

Mean Square Error

It is the aggregate distinction between the Zoomed picture with existing technique and Zoomed picture with proposed strategy. The equation is:

$$MSE = \frac{1}{HW}\sum_{i=1}^{H}\sum_{j=1}^{W}[X(i,j) - Y(i,j)]^2 \qquad (10)$$

Structure Similarity

It is utilized for measuring the multifaceted nature between Zoomed picture with existing technique and zoomed picture with proposed strategy. The equation is given as:

$$\text{SSIM}=\sum_{j=1}^{M}\sum_{k=1}^{N} x_{j,k}{}^2 \qquad (11)$$

Graphical representation of performance parameter is shown below: comparison of different techniques in Lena Image using peak signal Noise Ratio (PSNR) in figure 5, Mean Square Error (MSE) in figure 6, Signal Noise Ratio (SNR) in figure 7 and Structure Similarity index (SSIM) in figure 8.

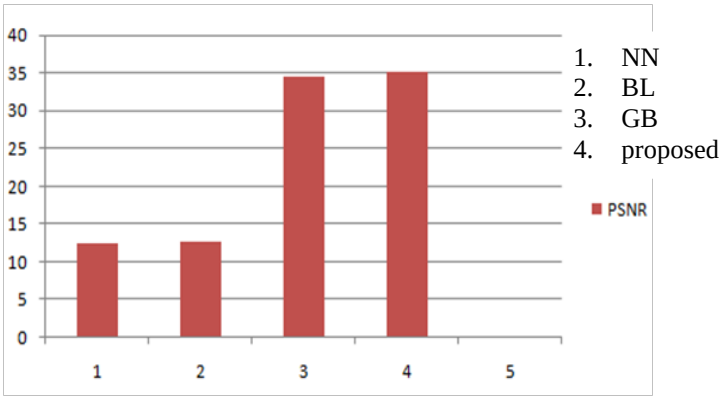

Figure 5. Comparison between Nearest Neighbor Method, Bilinear interpolation Method, Gradient Based Method and Proposed Method. in terms of peak Signal to Noise Ratio for Lena image

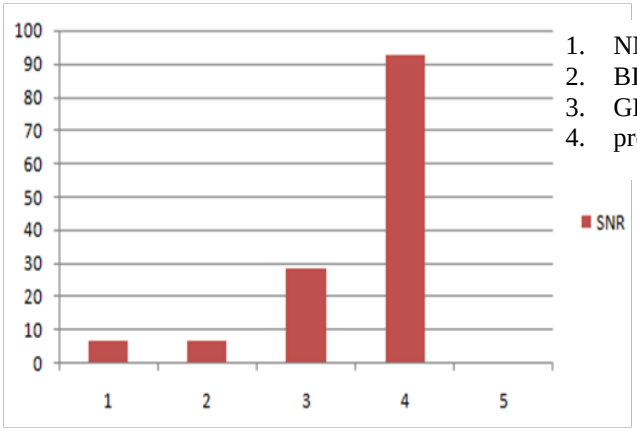

Figure 6. Comparison between different Techniques Nearest Neighbor Method, Bilinear interpolation Method, Gradient Based Method and Proposed Method in terms of Signal Noise Ratio for Lena image

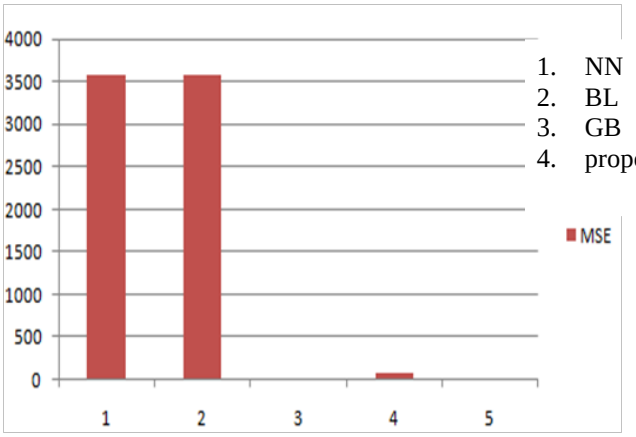

Figure 7. Comparison between different Techniques Nearest Neighbor Method, Bilinear interpolation Method, Gradient Based Method and Proposed Method in terms of Mean Square Error for Lena image

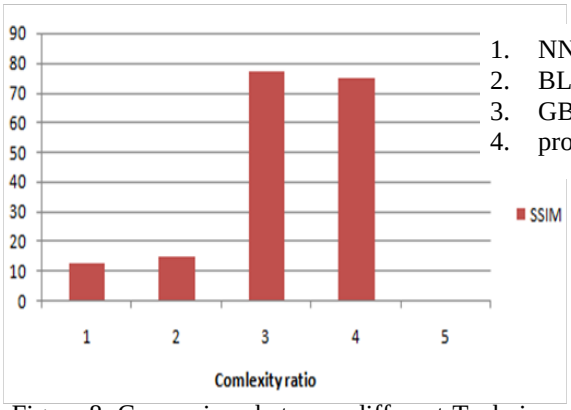

Figure 8. Comparison between different Techniques Nearest Neighbor Method, Bilinear interpolation Method, Gradient Based Method and Proposed Method in terms of Structure Similarity index for Lena image

Table1.
Comparison between Nearest Neighbor (NN) Method, Bilinear (BL) Method, Gradient Based (GB) Method and Proposed Method in terms of Elapsed Time, Mean Square Error, Signal Noise Ratio, Peak Signal Noise Ratio, Scaling Ratio and Structure Similarity index for Lena Image.

Parameters	**Interpolation Methods**			
	Nearest Neighbor Method	**Bilinear Method**	**Gradient Based Method**	**Proposed Method**
Elapsed Time	95.452652	86.3835	5.4169	92.4686
MSE	3583.3474	3573.0452	23.6395	92.4686
SNR	6.9639	6.9764	28.7704	23.9671
PSNR	12.5879	12.6004	34.3944	35.1728
Scaling Ratio	0.2505	0.2505	1	1
SSIM	12.29%	14.77%	76.97%	74.96%

Conclusion

In this paper various interpolation methods are studied and reviewed for scaling the digital image. The back propagation algorithm is used in proposed method which is one of the most useful algorithms of neural network. Back propagation algorithm is applied to replicate the pixels and only that pixels has been replicated which has last error in digital image where error is the difference between actual output and desired output layer. From the comparison of different techniques, nearest neighbor is easy to use and produced the image too blurred. Bilinear image is produced smoothness result and image quality is fairly blurred. The proposed method is evaluated using image quality matrix (IQM) like Peak Signal Noise Ratio (PSNR), Mean Square Error (MSE), Signal

Noise Ratio (SNR) and Structure Similarity index (SSIM) of an image. From experimental result of Lena image with scaling factor 1, it has been concluded that the proposed method reduced the complexity 74.96% of an image as compared Gradient Based method reduced complexity of an image is 76.97%. So, proposed method gives better result of Lena image as compare to Gradient Based method.

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