A New Approach for Image Scaling Using DWT Interpolation

Remimol.A.M¹, Sekar.K²

¹PG Scholar, ²Assistant Professor, Department of EEE, Hindusthan College of Engineering and Technology, Coimbatore, Tamil Nadu

fathimaremi@gmail.com

Abstract- Image scaling is a technique which scale down or scale up the pictures or video frames to fit to the application. This work proposes a new scaling algorithm for the implementation of image scaling. The proposed scaling algorithm is an area pixel scaling algorithm consisting of a Discrete Wavelet Transform (DWT) based interpolation and bicubic interpolation. To achieve higher visual quality, DWT interpolation is carried out first to the gray scale values of image and then bicubic interpolation is performed. A simple Haar wavelet based DWT is implemented. DWT is based on sub band coding, which divides the image into four frequency quadrants. To reduce the artifacts, bicubic interpolation is performed to all the quadrants separately. This work can achieve an image quality by a factor more than 10 dB than the existing bilinear interpolation method. The average Peak Signal to Noise Ratio (PSNR) is more and the mean square error is less in this method. The image artifacts like blurring can be greatly reduced and checkerboard effects are eliminated in the proposed method, thus this approach is better than existing methods in visual quality. The simulation of the work is carried out in MATLAB R2013a.

Keywords- Image scaling, Discrete wavelet Transform (DWT) interpolation, Bicubic interpolation, Peak Signal to Noise Ratio (PSNR).

I. INTRODUCTION

Image scaling is the process of resizing a digital image which has been widely used in many fields from consumer electronics to medical fields. Scaling is a non-trivial process that involves a trade-off between efficiency, smoothness and sharpness [1]. In the fields of digital imaging devices, image scaling has a very important role. An important application of image scaling is to scale down the high-quality pictures or video frames to fit to the application such as the mini size liquid crystal display panel of the mobile phone or tablet PC etc.

An image size can be scaled in two ways; up scaling and down scaling. Up scaling is an image enhancement process in which the size of the image is enlarged to fit to the desired application. It is the process of highlighting certain features of interest in an image.

Down scaling is the process of image compression which reduces the amount of data needed to represent a digital image. This is done by removing the redundant data from the image. The objective of image compression is to decrease the number of bits required to store and transmit image without any measurable loss of information.

Common interpolation algorithms can be grouped into two categories: adaptive and non-adaptive. Adaptive methods change depending on what they are interpolating (sharp edges vs. smooth texture), whereas non-adaptive methods treat all pixels equally. Non adaptive algorithms include: nearest neighbor, bilinear, bicubic, spline, sinc, lanczos and others. Nearest neighbor algorithm is the simplest method in which the scaled images are full of blocking and aliasing effects. Bilinear interpolation algorithm [2] is the most widely used scaling method, where the target pixel is obtained by the linear interpolation in both horizontal and vertical directions. Another popular non-adaptive method is bicubic interpolation algorithm [3], which is an extension of cubic model. These are some of the polynomial-based methods.

Adaptive algorithms include many proprietary algorithms in licensed software such as: Qimage, PhotoZoom Pro, Genuine Fractals and others. Many non-polynomial-based methods have been proposed in recent years, such as curvature interpolation [4], [5], and autoregressive model [6]. Some previous studies proposed area pixel scaling algorithms such as Winscale [7], edge enhanced scaling algorithm [8] and adaptive edge enhanced algorithm [9]. These methods efficiently enhance the image quality also reduce the image artifacts such as blocking, aliasing and blurring effects but these image scaling algorithms are characterized by high complexity and high memory requirement.

DWT is an interpolation technique [10], [11] which is performed with many types of wavelets. Haar wavelet based approach for image compression [12] is an efficient and simplest method for image scaling. In order to improve the quality of image than the previous works, DWT with bicubic interpolation is proposed in this work.
II. PROPOSED SCALING ALGORITHM

Fig.1. Shows the proposed scaling algorithm, which is an area pixel scaling algorithms consisting of a preprocessor, discrete wavelet transform based interpolation, bicubic interpolation and post-processor. Preprocessor converts the original image to gray scale values. To achieve higher visual quality, discrete wavelet transform based interpolation is carried out first and then bicubic interpolation. DWT is based on sub band coding, which divides the image into four frequency quadrants. To reduce the artifacts, bicubic interpolation is carried out to all the quadrants separately. Bicubic interpolation is an efficient method in which the horizontal and vertical interpolation with nearest 16 pixels is done, which improves the resolution of the image.

II A. Input Image

An image contains descriptive information about the object it represents. An image is defined as a two-dimensional function, \( f(x, y) \) that carries some information, where \( x \) and \( y \) are known as spatial or plane coordinates. The amplitude of ‘\( f \)’ at any coordinates \( (x, y) \) is called the intensity or gray level of the image at that point. The input image applying to the proposed method may be any JPEG (Joint Picture Experts Group) image. JPEG is a continuous tone still image compression standard.

II B. Pre Processor

Preprocessor converts the original digital image into gray scale values. The discrete levels in a pixel are integers which are assumed to be in the interval \([0, L-1]\) where \( L \) is the number of discrete gray levels allowed for each pixel. This should be an integer power of 2.

I.e., \( L = 2^k \) (1)

The range of values spanned by the gray scale \([0, L-1]\) is called the dynamic range of an image. If the dynamic range is high, then the image will have high contrast and if the dynamic range is low, the image will have a dull, washed out gray look.

II C. DWT Interpolation

Wavelet transform decomposes a signal into a set of basic functions. These basis functions are called wavelets. Wavelets are obtained from a single prototype wavelet \( y(t) \) called mother wavelet by dilations and shifting given by:

\[
\psi_{a,b}(t) = \frac{1}{\sqrt{a}} \psi\left(\frac{t-b}{a}\right)
\]

Where \( a \) is the scaling parameter and \( b \) is the shifting parameter.

In DWT interpolation of image first, the input image is divided into four quadrants according to frequency level. In the second level, each frequency quadrant is divided into sub quadrants and each of these sub quadrants splits according to frequency in the third level. DWT is a technique of decomposition of a complex signal in terms of its mother wavelet and is similar to the expansion of a function in the form of a series. The more the number of terms considered, the higher the accuracy. An image is a two-dimensional signal or a two-variable function. Hence, the series expansion is also two-dimensional. Haar wavelet is one of the oldest, simplest and efficient wavelet used for DWT interpolation.

II D. Bicubic Interpolation

After DWT interpolation, bicubic interpolation is carried out to each quadrant separately. Bicubic interpolation is the default pixel interpolation algorithm. It generates each target pixel by interpolation from the nearest sixteen mapped source pixels. The interpolation artifacts such as blurring and aliasing can be greatly reduced by bicubic interpolation.

II E. Post Processor

Post processing converts the interpolated gray scale values to original form and produces the scaled output.
The mean square error and peak signal to noise ratio is calculated for the scaled output image. To analyze the quality of the scaled image by the scaling algorithm, a peak signal-to-noise ratio (PSNR) is used to quantify a noisy approximation of the refined and the original images. PSNR is the ratio of signal quantity to noise quantity in an image. Since the maximum value of each pixel is 255, the PSNR expressed in dB can be calculated as:

\[
PSNR = 10 \log_{10} \left( \frac{255^2}{MSE} \right)
\]  (3)

Where, MSE is the mean square error, which is calculated as:

\[
MSE = \frac{1}{mn} \sum_{i=1}^{m} \sum_{j=1}^{n} (x_{ij} - y_{ij})^2
\]  (4)

Where \(m\) and \(n\) are the numbers of rows and columns, respectively, \(x_{ij}\) and \(y_{ij}\) denote the original and reconstructed signals, respectively, where \(i = 1 : m\) and \(j = 1 : n\).

### III. RESULTS AND DISCUSSION

The scaled output image of the proposed method shows that the resulting image is better than the existing bilinear interpolation. To evaluate the performance of the interpolation scheme, (Peak Signal to Noise Ratio) PSNR have been calculated which is expressed in decibel (dB). The average PSNR of the bilinear interpolation is 28.54. In this work PSNR value of two images with three different sizes are verified. From the simulation result, the image “crome” has an average PSNR of 40.49 and image “use” has an average PSNR of 41.26, as shown in Table:1 and Table:2, which means that the image quality is improved by a factor of more than 10 dB. The blurring and aliasing effects in the existing method are greatly reduced. Thus, from this simulation result it is clear that the proposed DWT with bicubic interpolation is better in image quality than the existing bilinear method.

<table>
<thead>
<tr>
<th>Size</th>
<th>PSNR (dB)</th>
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<tbody>
<tr>
<td>204x204</td>
<td>33.01</td>
</tr>
<tr>
<td>306x306</td>
<td>45.12</td>
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<tr>
<td>184x184</td>
<td>43.35</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>40.49</strong></td>
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<table>
<thead>
<tr>
<th>Size</th>
<th>PSNR (dB)</th>
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<tr>
<td>299x169</td>
<td>41.14</td>
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<tr>
<td>240x136</td>
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<tr>
<td>537x303</td>
<td>48.13</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>41.26</strong></td>
</tr>
</tbody>
</table>

The simulation results of down scaling and up scaling are shown in Fig.2. and Fig.3. A JPEG image ‘crome’ is interpolated in this work.

**Fig. 2. Down Scaled Crome Result**

The down scaled result of image crome by a factor 0.5 is shown in the Fig.2. in which, Figure i shows the original image and Figure ii shows the down scaled image.
The row and column pixel values of original image are 258 and 774. When it is interpolated, the row and column values changed to 128 and 384 respectively. The PSNR and MSE values of down scaled image crome are obtained as: MSE = 27 and PSNR = 33.8172dB.

Thus this work can achieve better image quality than the existing bilinear interpolation method. The simulation of the work is carried out in MATLAB R2013a.

REFERENCES


