Design and Verification of Soft Decision Adaptive Interpolation Modal for Image Interpolation

Dinabandhu Kumar
Student
Department of Control System
Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India

Abstract— In computer graphics, image interpolation is the process of resizing a digital image. Interpolation is a non-trivial process that involves enhancement in sense of efficiency, smoothness and sharpness. With bitmap graphics, as the size of an image is enlarged, the pixels that form the image become increasingly visible, making the image appear "soft" if pixels are averaged, or jagged if not. Image interpolation methods however, often suffer from high computational costs and unnatural texture interpolation. This work intends to give an efficient algorithm which enhances the LR image to HR with enhanced PSNR and time complexity. The work has been designed and tested on MATLAB 2016 simulator.

Key words: CUDA (Compute Unified Device Architecture), PAR (Pixel Accept Ratio), PEE (Percentage Edge Error), PSNR (Peak Signal to Noises Ratio), NN (Nearest Neighbours)

I. Introduction

Image interpolation refers to constructing a high-resolution (HR) image from a low-resolution (LR) image. In the mathematical field of numerical analysis, interpolation is a method of constructing new data points within the range of a discrete set of known data points. In engineering and science, one often has a number of data points, obtained by sampling or experimentation, which represent the values of a function for a limited number of values of the independent variable. It is often required to interpolate (i.e. estimate) the value of that function for an intermediate value of the independent variable. This may be achieved by curve fitting or regression analysis.

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 storing 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 becomes the pre-processing step for other image processing tasks like image registrations, image rotation. Image registration needs interpolation to accurately register the image at sub-pixel level.

Regression analysis is a set of statistical processes for estimating the relationships among variables. It includes many techniques for modelling and analysing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables (or 'predictors'). More specifically, regression analysis helps one understand how the typical value of the dependent variable (or 'criterion variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed.

Many image interpolation techniques are already been developed and designed we are proposing a new method is been used for edge-adaptive image interpolation which uses Newton forward difference. This difference provides very good grouping of pixels ones we consider target pixel for interpolation Proposed approach estimates the enlarged image from the original image based on an observation model. The estimated image is constrained to have many edge-directed smooth pixels which are measured by using the edge-directed smoothness filter. Simulation results for the work will can get by MATLAB and expecting that for the proposal method it will produces images with higher visual quality, higher PSNRs and faster computational times than the conventional methods.

Nearest Neighbour method for image interpolation: This is the simplest form of interpolation, where the interpolated pixel value determined by nearest neighbour in the proximity. Simplicity of calculation is the reason for its cheap computational cost. This interpolation also called pixel replication.

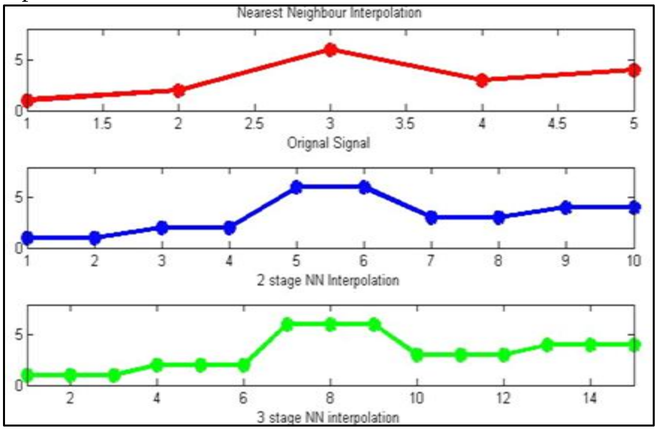

Fig. 1: Nearest Neighbour Interpolation

Bilinear method for image interpolation: As the name suggests, it is linear interpolation in two directions, first in horizontal direction then by a vertical direction or vice-versa. Bilinear interpolation uses weighted average of the 4 neighbourhood pixels to calculate its final interpolated pixel. Bilinear interpolation performs better than NN as reduction of the stair-case effect makes the image looks smother.

However, blurring effect is occurred by averaging the surround pixels. Since the pass-band is attenuated moderately, it causes smoothing of image.

Linear Interpolation: procedure is easy and was very popular in signal processing especially when Um-sampling is required in processes for linear interpolation liniar line drawn at known place and empty space. Cut points considers as value which is to be fit.

It can be understood from example below: - let original Signal is

x= [1; 2; 6; 3; 4]

x1=[1; 1.5; 2; 4; 6; 4.5; 3; 3.5; 4]

x2= [1; 1.3333; 1.667; 2; 3.3333; 4.667; 6; 5; 4; 3; 3.333;3.667;4].

Interpolation kernel for linear interpolation samples the input with the following kernel.

Interpolation techniques are mainly divided in two categories:

- Non-adaptive techniques
- Adaptive techniques

Non-adaptive interpolation techniques are based on direct manipulation on pixels instead of considering any statistical feature or content of an image. These are kernel based interpolation techniques where unknown pixel values are found by convolving with kernel. Hence they follow the same pattern of calculation for all pixels. Moreover most of them are easy to perform and have less calculation cost. Various non-adaptive techniques are nearest neighbor, bilinear, bicubic, etc.

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 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. Various adaptive techniques exist for image interpolation NEDI, DDT, ICBI, etc.

II. METHODOLOGY

Conventional bilinear interpolation (2 pixels), cubic convolution interpolation (4 pixels), cubic spline interpolation (4 adjacent pixels), these classical algorithms can lead to interpolation artifacts such as blurring, ringing, jaggies, and zippering.

To preserve edge structures in interpolation, Li and Orchard proposed to estimate the covariance of HR images from the covariance of LR images, and to then interpolate the missing pixels based on the estimated covariance.

Zhang and Wu present SAI (soft-decision adaptive interpolation) which use 2-D autoregressive model, but the core of autoregressive models was a time-cost approach, which makes it difficult to meet the requirements of real-time reconstruction in actual production.

SAI image modal can be presented as

$$X(i,j) = \sum_{(m.n)\in W} \alpha(m,n)X(i+m,j+n) + v_{i,j} \dots (1)$$

α(m,n) is the autoregressive coefficient Li and Orchard SAI modal use gauss siedel regression modal to compute α(m,n). As per proposed work first we do HSV colour stretching then go for estimate the unknown pixels using known pixels A is a 16x4 matrix for the sub image as shown in below figure developed for diagonal four 8-connected neighbours. B is 16x4 matrix for the sub image as shown in below developed for vertical four of 4-connected neighbors.

$$a = (A^T A)^{-1} A^T x)$$

$$b = (B^T B)^{-1} B^T x)$$

To compute 9 unknown pixels of y= [y1, y2….y9]

$$y = (C^T C)^{-1} C^T D x$$

Where

$$C = \begin{bmatrix} I9 \\ H \end{bmatrix}$$

	1	0	0	0	0	0	0	0	0
	0	1	0	0	0	0	0	0	0
	0	0	1	0	0	0	0	0	0
	0	0	0	1	0	0	0	0	0
	0	0	0	0	1	0	0	0	0
	0	0	0	0	0	1	0	0	0
C	0	0	0	0	0	0	1	0	0
	0	0	0	0	0	0	0	1	0
	0	0	0	0	0	0	0	0	1
	a1	a2	0	a3	a4	0	0	0	0
	0	a1	a2	0	a3	a4	0	0	0
	0	0	0	a1	a2	0	a3	a4	0
	0	0	0	0	a1	a2	0	a3	a4
	0	-b1λ	0	-b3λ	1	-b4λ	0	-b2λ	0

Table 1

a1	a2	0	0	a3	a4	0	0	0	0	0	0	0	0
0	a1	a2	0	0	a3	a4	0	0	0	0	0	0	0
0	0	a1	a2	0	0	a3	a4	0	0	0	0	0	0
0	0	0	a1	a2	0	0	a3	a4	0	0	0	0	0
0	0	0	0	a1	a2	0	0	a3	a4	0	0	0	0
0	0	0	0	0	a1	a2	0	0	a3	a4	0	0	0
0	0	0	0	0	0	a1	a2	0	0	a3	a4	0	0
0	0	0	0	0	0	0	a1	a2	0	0	a3	a4	0
0	0	0	0	0	0	0	0	a1	a2	0	0	a3	a4
0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2

Let’s have an example as below

5		4		2		1		1		0
4		6		3		2		0		5
			3		2		1			
3		4		0		1		2		6
			3		3		1			
4		5		6		3		3		1
			4		2		4			
1		2		3		2		0		5
0		5		5		6		2		1

For the above matrix after performing proposed algorithm we got 9 unknown pixels with the help of 36 known pixels. Yellow colour represents the value of unknown pixels.

A. Steps of Performing Proposed Work

Flow for proposed algorithm as follow:

1) Step 1: capture or choose any image in any YUY or RGB format, image should be a low resolution image which we require to interpolation.
2) Step 2: Perform HSV (Hue, Saturation amd Value) stretching is in order to enhancing quality for image, MAX is maximal value in R, G, B for all pixels in image, and MIN is minimal one.

$$\begin{cases} Undefine & if\ MAX = Min \\ 60X\dfrac{G-B}{MAX-MIN}+0 & if\ MAX = R\ and\ G \geq B \\ 60X\dfrac{G-B}{MAX-MIN}+360 & if\ MAX = R\ and\ G < B \\ 60X\dfrac{B-R}{MAX-MIN}+120 & if\ MAX = G \\ 60X\dfrac{R-G}{MAX-MIN}+240 & if\ MAX = B \end{cases}$$

$$S=\begin{cases} 0 & if\ MAX = 0 \\ 1-\frac{MIN}{MAX} & otherwise \end{cases} \quad V=MAX$$

3) Step 3: Perform Proposed interpolation as explain above it will produce a horizontally interpolated image.
4) Step 4: Perform image filtering in order to having a good final image.

III. RESULTS

Fig. 2: Simulation result for Lina image

Fig. 3: Simulation result for peppers image

Fig. 4: Simulation result for bacterial image

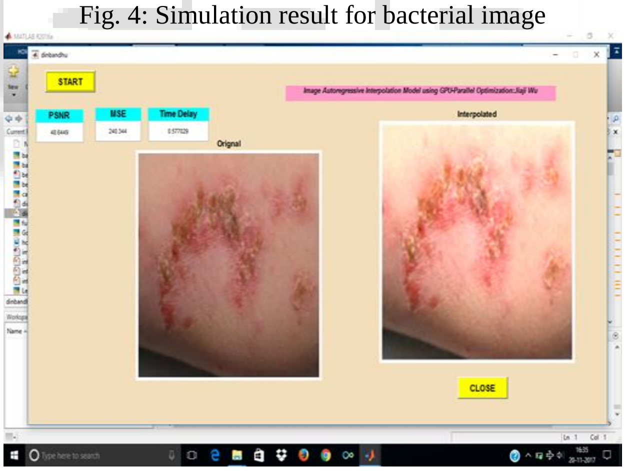

Fig. 5: Simulation result for viral skin image

Fig. 6: Simulation result for fungal skin image

IMAGE	PSNR(db)	MSE	EXECUITION TIME(S)
Lina	48.1539	254.323	0.544775
Peppers	48.2626	251.161	0.564098
Bacterial skin	48.4107	246.915	0.496805
Viral skin	48.6449	240.344	0.577029
Fungal skin	48.5294	243.561	0.576632

Table 3: Results

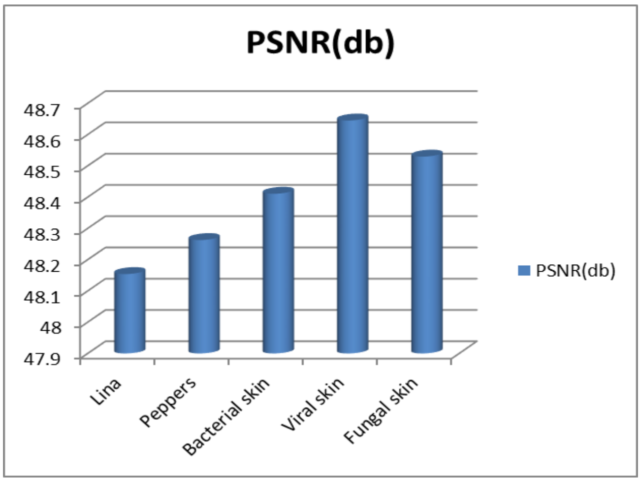

Fig. 7: Bar chart PSNR in db

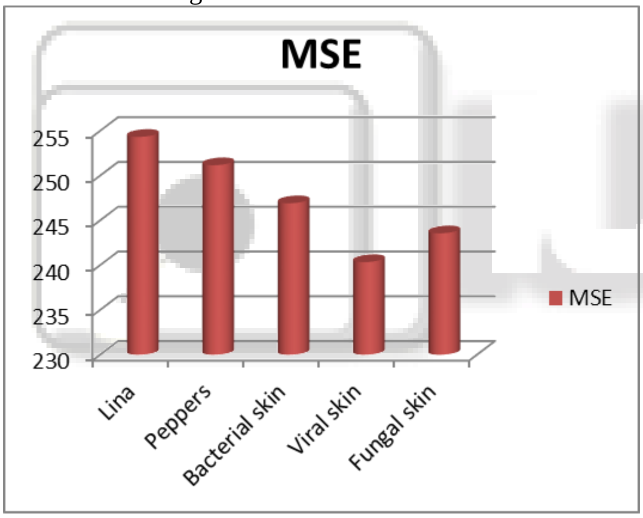

Fig. 8: Bar chart MSE

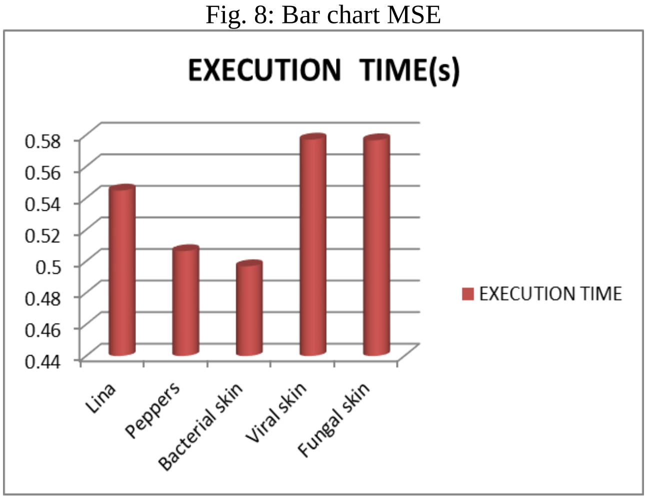

Fig. 9: Bar chart Execution Time

A. *Comparative Results*

Author	Outcome(PSNR)
W Dong, Lei Zhang	31.11db
Delibasis, K.K, Kechriniotis	32.77db
Cateshuyuanzhu	34.85db
Tudor Barbu	31.27db
Jiaji Wu	34.58db
Proposed work	48.1539db

Table 4: comparative Result

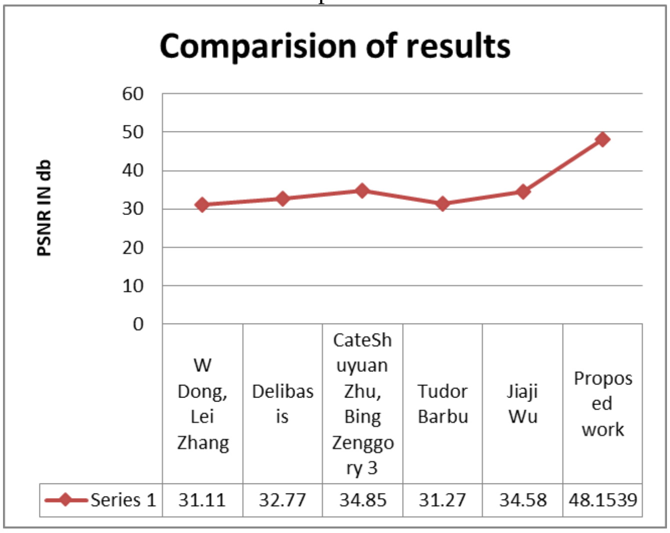

Fig. 10

IV. CONCLUSION

As interpolation is the technique which is used for improving and modification of image, video or any other data, so many interpolation techniques are been developed in the area, basically interpolation was the application of signal processing now it has versatile uses. One can conclude that after implementation of our defined approach of interpolation we will have very good and better quality of image as desired modification in it. One can also conclude that the time taken for the process will not be higher than existing work and proposed work will have better PSNR and MSE then existing work.

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