IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

AN APPROACH FOR VIDEO SCALING USING INTERPOLATION TECHNIQUES

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Abstract: Now a days, we can watch movies, videos on different video displaying devices ranging from mobile phone, iPods to high definition television displays. These devices have different size and resolutions. Movie contents often are manufactured in one resolution and consumed in other resolutions. Therefore it is necessary to convert video from one resolution format to other format which is compatible with particular display device. Converting video from lower resolution to higher resolution is known as video up scaling and converting video from higher resolution to lower is known as video down scaling. Video scaling is converting video from one resolution format to another, so that video will fit into target display. In this project we are converting video from QCIF, CIF format to VGA format using adaptive decision algorithm. Adaptive decision algorithm uses Spline interpolation for if difference between two adjacent pixels is more than threshold, and uses Nearest neighborhood if difference is less than threshold. QCIF format is widely used in mobile phone, iPod displays. VGA is well known computer monitor display format

***Index Terms* – Image scaling, Zooming, Interpolation, nearest neighbor, bilinear, spline, box filter, Bartlett filter, MSE, PSNR, Quality index.**

1. INTRODUCTION

An image may be defined as a two-dimensional function f(x, y), where x and y are *spatial* (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the *intensity* or *gray level* of the image at that point. The field of *digital image processing* refers to processing digital images by means of a digital computer. Digital image processing involves the use of computer algorithms to perform image processing on digital images. The usefulness is apparent in many different disciplines covering medicine through remote sensing. The advances and wide availability of image processing hardware has further enhanced the usefulness of image processing. The Application of Digital Image Processing includes Medical Applications, Restorations and Enhancements, Digital Cinema, Image scaling, Image compression, Image Transmission and Coding, Color Processing, Remote Sensing, Robot Vision, Hybrid Techniques, Facsimile, Pattern Recognition, Registration Techniques, Multidimensional Image Processing, Image Processing Architectures and Workstations, Video Processing, Programmable DSPs for Video Coding, High-Resolution Display, High-Quality Color Representation, Super-High-Definition Image Processing, Impact of Standardization on Image Processing.

Due to the restriction of resolution or display size of mobile devices, spatially downscaled or down sampled video/image is provided for the display. But user may not be satisfied the small sized video/image and may want to see the video/image with larger resolution. The better solution to satisfy the viewer is to define the region of interest to view the video/image. Even if the display size is same, semantically meaningful region can be defined with better resolution. In most of the videos/images, certain region is more important than the other regions in the video/image. For example, people in the picture are more meaningful than background.

The video/images, binary images or pseudo-binary images such as documents and signatures are major inputs required to process for mobile vision applications. To process these inputs on mobile devices, computational complexity or computation time and memory required to fit the image scaling techniques become crucial. Hence the fast interpolation techniques which gives reasonably good quality are required to process (scale) these inputs are required. When an image is geometrically transformed for scaling purpose, a pixel in the new image is often projected back to a point with non-integer coordinates in the original image.

II. RESEARCH METHODOLOGY

Interpolation is reconstructing function from set of known values. There are many interpolating techniques which are optimized for different aspects like number of computations required, accuracy, accuracy of first order derivative etc. The ideal interpolating technique is one which gives less error with less number of computations. In this section we discuss some of the interpolation techniques.

2.1 Nearest neighborhood interpolation

Nearest Neighbor Interpolation is the simplest interpolation method, determines the value of the pixel from the closest pixel to the specified input coordinates, and assigns that value to the output coordinates. Nearest neighborhood interpolation just copies existing values to new pixels. For one-dimension Nearest Neighbor Interpolation, the number of grid points needed to evaluate the interpolation function is two. For two-dimension Nearest Neighbor Interpolation, the number of grid points needed to evaluate the interpolation function is four.

2.2 Bilinear interpolation

Bilinear Interpolation determines the colour component value from the weighted average of the four closest pixels to the specified input coordinates, and assigns that value to the output coordinates.
In Bilinear interpolation First, two linear interpolations are performed in one direction (either horizontal or vertical) and then one more linear interpolation is performed in the perpendicular direction (vertical or horizontal).
If we know values of function at four points in a plane then bilinear approximation of planar function is given by

$$f(x,y) = \frac{f(Q_{11})}{(x_2-x_1)(y_2-y_1)}(x_2-x)(y_2-y) + \frac{f(Q_{21})}{(x_2-x_1)(y_2-y_1)}(x-x_1)(y_2-y) + \frac{f(Q_{12})}{(x_2-x_1)(y_2-y_1)}(x_2-x)(y-y_1) + \frac{f(Q_{122})}{(x_2-x_1)(y_2-y_1)}(x-x_1)(y-y_1) \quad (1)$$

Where $Q_{11}=(x_1, y_1)$, $Q_{21}=(x_2, y_1)$, $Q_{12}=(x_1, y_2)$ and $Q_{22}=(x_2, y_2)$ are points where value of function is known.

2.3 Bicubic interpolation

Cubic interpolation determines the colour component value of pixel from the weighted average of the 16 closest pixels to the specified input coordinates, and assigns that value to the output coordinates. The video frame is sharper than that produced by Bilinear Interpolation, and it does not have the disjointed appearance produced by Nearest Neighbor Interpolation.
First, cubic interpolation is performed in horizontal direction and then in vertical direction. The one dimensional cubic approximation is done either Lagrange polynomials or other cubic polynomials. For one-dimension Cubic Interpolation, the number of points needed to evaluate the interpolation function is four, two grid points on either side of the point under consideration. For Bicubic Interpolation, the number of grid points needed to evaluate the interpolation function is 16.

2.4 Cubic Spline interpolation

In order to get higher accuracy level we must increase degree of interpolating polynomial. But it requires more computations. Piecewise interpolation methods are developed in order to achieve higher level of accuracy with low degree polynomials. Cubic spline interpolation is piecewise interpolation. First, second and third ordered derivatives of spline interpolation are continuous over given interval.
For equi-spaced points the spline interpolation formula in interval $[x_{i-1}, x_i]$ is given by,

$$F(x) = \frac{1}{6h}[(x_i - x)^3 M_{i-1} + (x - x_{i-1})^3 M_i] + \frac{1}{h}(f_{i-1} - \frac{h^2}{6}M_{i-1})(x_i - x) + \frac{1}{h}(f_i - \frac{h^2}{6}M_i)(x - x_{i-1}) \quad (2)$$

M_i arecomputed using, $M_{i-1} + 4M_i + M_{i+1} = \frac{6}{h^2}(f_{i+1} - 2f_i + f_{i-1})$

and $M_0 = Mn = 0$. (3)

2.4Adaptive hybrid video scaling algorithm

Video interpolation techniques like nearest neighborhood, Bi-linear interpolation require less number of computations. But gives less accuracy. The video interpolation techniques like spline interpolation, Bi-cubic interpolation give better quality but the number of computations required is very high compared to nearest neighborhood, Bilinear interpolation. In this method both techniques are combined to give better quality with less number of computations.

2.5 Adaptive decision method

In adaptive decision method interpolation is carried out separately along x and y direction. The value of difference between two pixels is computed. If the difference between two adjacent pixels is less than threshold then the nearest neighborhood interpolation is chosen, if the difference is greater than threshold then spline interpolation is used for interpolation. Since nearest neighborhood require less number of computations and spline interpolation is accurate this method gives comparatively better quality with less number of computations.

III. IMPLEMENTATION DETAILS

The experiments are conducted at NMIT Research center for different sets of input video of various file formats. The different interpolation algorithms considered are nearest neighbor, bilinear and spline interpolation for the comparison using different parameters such as MSE, PSNR, and quality index.etc. The digital signal processor multimedia developer kit DM 642 operating at 600 MHZ is considered for the experimentation. All the source files are written in C programming language. The DM642 DSP is capable of executing eight instructions in parallel at the clock speed of 600 MHz If we are able to utilize these execution units then we can benefit from its processing power and obtain a high performance solution. Otherwise, the performance may not be satisfactory. The un-optimized codes for different interpolation techniques are considered for validation.
The display resolution of a display device is the number of distinct pixels in each dimension that can be displayed. There are various display resolution formats used in different display devices shown in table 1

Table 1: Various display resolution formats

Format Name	Aspect ratio	Height	Width
CIF	4:3	288	352
QCIF	1.2:1	144	176
VGA	5:4	480	640
XGA	4:3	1024	768
XGA+	4:3	1152	864
WXGA	5:3	1280	768
WXGA	8:5	1280	800
UVGA	4:3	1280	960
SXGA	5:4	1280	1024
WSXGA	8:5	1440	900
HD+	16:9	1600	900
UXGA	4:3	1600	1200
WSXGA+	8:5	1680	1050
FULL HDTV	16:9	1920	1080
WUXGA	8:5	1920	1200

The different comparison parameters considered are MSE, PSNR, quality index, average difference, maximum difference, structural content, normalized absolute error and normalized cross correlation. Also, the algorithms are compared by estimating the memory required to fit the code and computation time required for computation.

3.1 Mean Square Error (MSE)

The Mean Square Error measures the difference between the frames which is usually applied to Human Visual System. It is based on pixel-pixel comparison of the image frames. Minimizing the MSE is equivalent to least-squares optimization in a minimum energy sense, for which many mathematical tools are available. MSE is still popular despite its inability to reliably predict perceived quality across different scenes and distortion types.

$$d(X,Y) = \frac{\sum_{i-1}^{m,n}{}_{j-1}(X_{i,j}-Y_{i,j})^2}{mn} \quad (4)$$

3.2 Peak Signal to Noise Ratio (PSNR)

PSNR is measured on a logarithmic scale and depends on the mean squared error (MSE) of between an original and an impaired image or video frame, relative to $(2^n-1)^2$ (the square of the highest-possible signal value in the image, where n is the number of bits per image sample).

$$PSNR_{db} = 10log_{10}\left(\frac{(2^n-1)^2}{MSE}\right) \quad (5)$$

PSNR can be calculated easily and quickly and is therefore a very popular quality measure, widely used to compare the 'quality' of images.

3.3 Quality Index

Image quality index measurement does not depend on the image being tested, the viewing conditions or the individual observers. More importantly it must be applicable to various image processing applications and provide meaningful comparison across different types of image distortions.

$$\boldsymbol{Q} = \frac{4\sigma_{xy}\bar{x}\bar{y}}{(\sigma^2{}_x+\sigma^2{}_y)[(\bar{x}^2)+(\bar{y}^2)]} \quad (6)$$

Where

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i \ , \quad \bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i \quad (7)$$

$$\sigma^2{}_x = \frac{1}{N-1}\sum_{i=1}^{N}(x_i-\bar{x})^2,\ \sigma^2{}_y = \frac{1}{N-1}\sum_{i=1}^{N}(y_i-\bar{y})^2, \quad (8)$$

$$\sigma_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}(x_i-\bar{x})(y_i-\bar{y}) \quad (9)$$

The dynamic range of Q is [-1,1].the best value of 1 is achieved if and only if $y_i = x_i$ for all i=1,2……….N. the lowest value of -1 occurs when $y_i = 2\bar{x} - x_i$ for all i=1,2…..N.

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

Experiments are conducted for different set of images of different resolution and file formats. A sample of the result is displayed for the further discussion. Different comparison parameters such as MSE, PSNR, and Quality index and computation time are considered. The figure indicates some of the input images considered for the experimentation

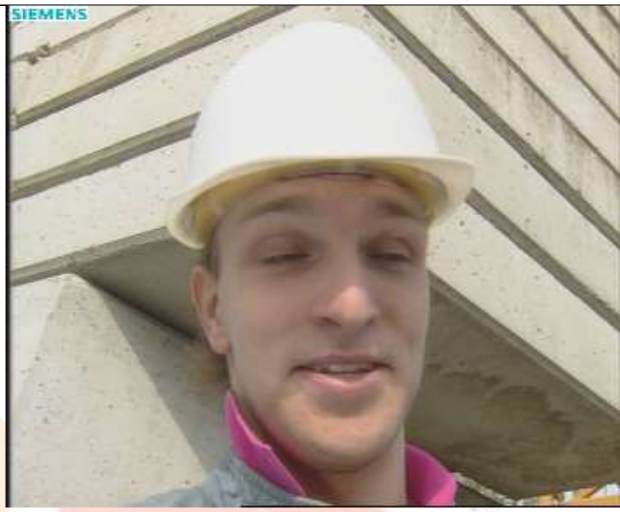
INPUT VIDEOS (QCIF) CONSIDERED FOR EXPERIMENTATION

Figure 1: Input Videos considered

			
BRIDGE	FOREMAN	HIGHWAY	MOTHER

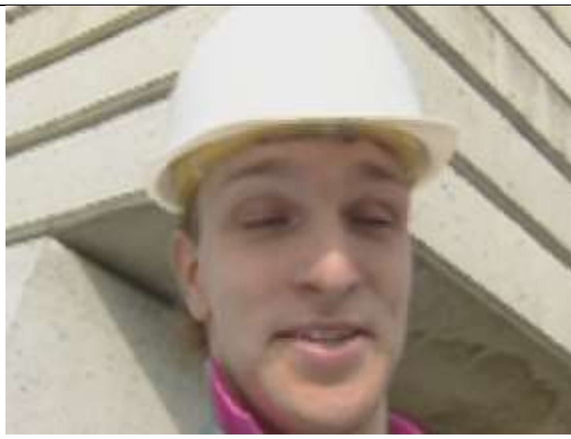
QCIF TO CIF CONVERSION

Figure 2: Output Videos after scaling using Interpolation techniques (Spline interpolation)

	
BRIDGE	FOREMAN
	
HIGHWAY	MOTHER –DAUGHTER

QCIF TO VGA CONVERSION

Figure 3: Output Videos after scaling using Interpolation techniques (Spline interpolation)

BRIDGE	FOREMAN
	
HIGHWAY	MOTHER-DAUGHTER

QCIF TO CIF CONVERSION

Table 2: Comparison parameters for different videos considered (Spline interpolation)

VIDEO	MSE	MAE	Quality Index	PSNR	SSIM
Highway	90.28	4	0.9908374	28.5115949	0.990855
Bridge	177.63	6.68	0.96385	25.70175	0.96418
Mother and Daughter	55.50	3	0.979625	30.688	0.978593
Foreman	102.88	4.52	0.981669	28.009	0.9818446

QCIF TO VGA CONVERSION

Table 3: Comparison parameters for different videos considered (Spline interpolation)

VIDEO	MSE	MAE	Quality Index	PSNR	SSIM
Highway	14.82	2	0.9907150	36.4298	.990835
Bridge	354.13	9	0.95231	22.629	0.95265
Mother and Daughter	25.50	2	0.936425	34.066237	0.942739
Foreman	71.32	4	0.98649	29.6102	0.98677

Table 4: Comparison results for different interpolation methods (FOREMANN Video)

METHOD	MSE	MAE	Quality Index	PSNR	SSIM
Nearest neighborhood	105.47	4.0	0.98944	27.9040	0.98835
Bilinear	95.93	5.0	0.99026	28.3240	0.99016
Bi-cubic	88.90	3.2	0.99115	28.6437	0.99125
Spline	81.13	3.0	0.99186	29.0406	0.99193

Figure 1 shows the different video considered for experimentation (displaying only one frame from a video). The different interpolation algorithms such as Nearest Neighbor, bilinear, bicubic and spline are applied for different videos. The output video frame is displayed for further discussion and analysis. Figure 2, 3 indicated the output video frame obtained by converting the video from QCIF to CIF and QCIF to VGA respectively. Table 2, 3 indicated the comparison parameter results for different videos. Table 4 indicates the comparison between different interpolation methods for the video FOREMANN.

V. SUMMARY AND CONCLUSIONS

From the experimental results, it is clear that Spline interpolation based algorithmic approach yields better results than nearest neighbor and bilinear interpolation. The proposed approach can be used to scale-up the QCIF format or CIF format to any resolution such as QVGA, VGA, etc. The proposed approach can be used iteratively to convert from the given image/video format to required display resolution by padding with necessary number of zeros or duplication required number of rows and columns.

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