Image Scaling Processor using Bilinear Algorithm

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ABSTRACT
Image scaling is widely used in many fields. A high quality image scaling is need of the hour. The proposed scaling algorithm consists of a sharpening filter, clamp filter and bilinear interpolation, to reduce the blurring and the aliasing effect and prefilters are added to the design. The proposed filter reduces the complexity and the hardware cost.

Keyword:
sharpening spatial filter, clamp filter, image zooming, reconfigurable calculation unit.

1. INTRODUCTION
Image scaling has been widely applied in the fields of digital imaging devices such as digital cameras, digital video recorders, digital photo frame, high-definition television, mobile phone, tablet PC, etc. An obvious application of image scaling is to scale down the high-quality pictures or video frames to fit the mini size liquid crystal display panel of the mobile phone or tablet PC. As the graphic and video applications of mobile handset devices grow up, the demand and significance of image scaling are more and more outstanding.

In many applications, from consumer electronics to medical imaging it is desirable to improve the restructured image quality and processing performance of hardware implementation. The image scaling algorithm is of two types they are polynomial based and non polynomial based algorithms[6].The simplest polynomial based algorithm is the nearest neighbor algorithm. The nearest neighbor algorithm is easy to implement and has less complexity but the images produced are of full of blocking and aliasing artifacts.

The bilinear interpolation is another polynomial based algorithm which uses linear interpolation model to calculate the value of the unknown pixels. The image produced by the bilinear interpolation method is popular due to its computational efficiency and image quality. The image produces blurring and aliasing effect upon scaling. The bicubic interpolation algorithm which is a extension of the cubic interpolation for interpolating pixels on a 2D regular grid. The images produced by the bicubic image interpolation is of high quality but it has high complexity and high memory requirements which makes it difficult to implement it in a Very large scale Integration(VLSI).The non polynomial based algorithm used in image scaling processor are auto regressive model bilateral filter and curvature interpolation. The area pixel mode of algorithm called Winscale[2] was proposed by kim.

The Winscale algorithm uses a maximum of four pixels and calculates the luminosity of each pixel from grey scale to color image. The Winscale algorithm more computing resource than the other algorithm. The bilinear algorithm has low complexity and memory requirement than the other algorithms.The blurring and the aliasing effect caused by the linear interpolation is can be smoothed by using a sharpening and clamp filter.

2. BILINEAR INTERPOLATION AND FILTERS
Bilinear interpolation is a image restoring algorithm which interpolates the neighboring pixels of an unrestored image to obtain the pixel of a restored image. The linear interpolation is done in one direction and then same function is repeated in other directions. Bilinear interpolation takes four neighboring pixels to calculate the target pixel. Bilinear interpolation is popular interpolation technique used in image scaling.

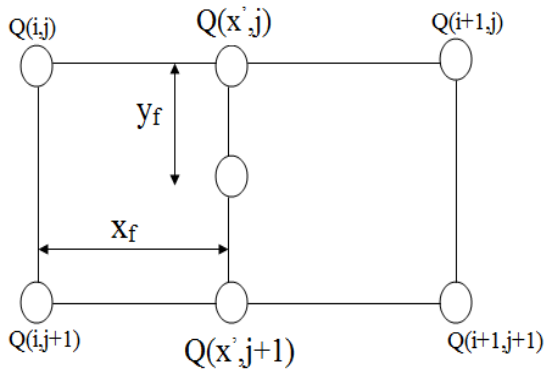


Figure 1:Bilinear Interpolation

The Q(i,j),Q(i+1,j),Q(i,j+1) and Q(i+1,j+1) are the nearest neighbor pixel of the original image with i=[0,1,2,…M] and j=[0,1,2…N]. Where M is the number of pixels having the width of the original image and N is the number of the pixels corresponding to the length of the image. The temporary pixel created by the vertical and the horizontal direction is as shown.

$$p(x', j) = (1 - x_f) \times p_{(i,j)} + x_f \times p_{(i+1,j)} \quad (1)$$

$$p(x', y') = [(1 - x_f) \times p_{(i,j+1)} + x_f \times p_{(i+1,j)}] \times (1 - y_f) + [(1 - x_f) \times p_{(i,j+1)} + x_f \times p_{(i+1,j+1)}] \times y_f \quad (2)$$

Where x_f is the scale parameter in the horizontal direction and y_f is the scale parameter in the vertical direction. Bilinear interpolation is popular implementation in the VLSI chips.

3. PROPOSEDSCALINGALGORITHM

The bloc k diagram for the proposed scaling is as shown. It consists of the sharpening spatial filter, a clamp filter and bilinear interpolator. The spatial and the clamp filters are used in reducing the blurring and the aliasing effect produced by the bilinear interpolation. The sharpening spatial filter is used to enhance the edges of the image and remove the unwanted noise present in the image. The filtered pixels are filtered by the clamp filter to smooth the unwanted discontinuous edges present at the boundary regions. The filtered pixels are then passed to the bilinear interpolation for up and down scaling.

To simply the computing resource and the memory requirement filters are combined into combined filter. The sharpening spatial is a high pass filter that is used in reducing the blurring effect and it is defined by a Kernel to intensity of the centre pixel with respect to its neighboring pixels

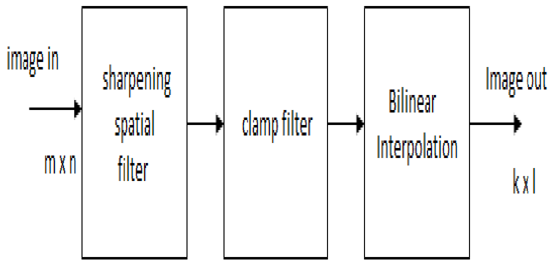


Figure 2 : block diagram of proposed block diagram

The clamp filter is used in removing the blurring the images and it reduces the noise present in the images .The clamp filter is a low pass filter which i can be converted into a convolution kernel.

$$\text{Kernel} = \begin{bmatrix} -1 & -1 & -1 \\ -1 & C & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

The kernel usually contains a single positive value surrounded by a negative values .The above kernel shows a example of a 3x3 array of an clamp filter .The sharpening filter is used in enhancing the edges of the edges of the image and it is extremely useful in removing the noise present in images. The kernel for the images is as shown.

$$\text{Kernel}= \begin{bmatrix} -1 & -1 & -1 \\ -1 & S & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

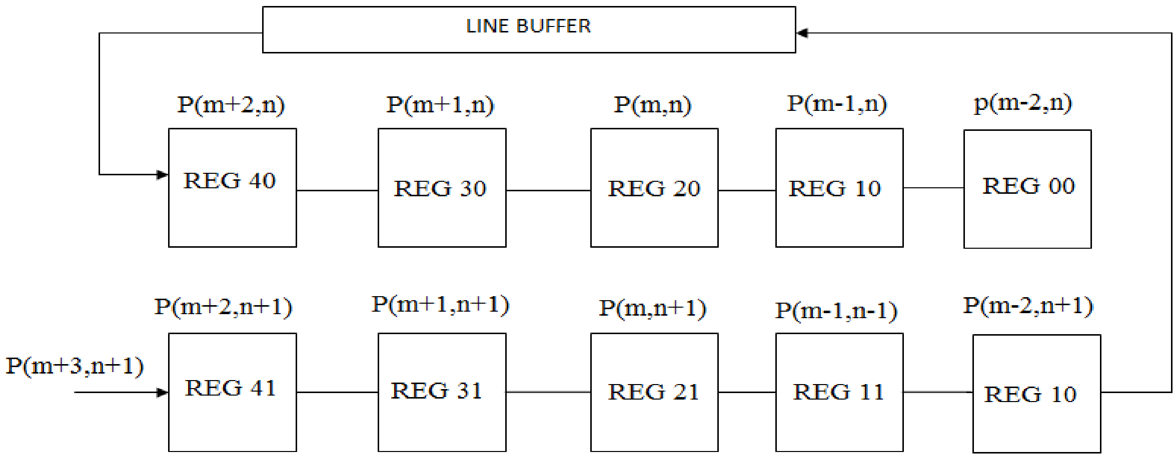


Figure 3: Block diagram of the register bank

The clamp filter is a low pass filter which consist of a Gaussian space domain filter and a convolution kernel array .The clamp is usually contains a positive value and it is surrounded by ones. The clamp filter is used in reducing the aliasing effect and smoothing the discontinuous edges of the boundary regions in a image. The sharpening spatial and clamp filters can be represented by a convolution kernel .A large size of the convolution kernel will produce a higher quality image. The large size of the convolution kernel occupies more memory and the hardware cost will be high.

To reduce the complexity and the memory requirement of the convolution kernel ,T model and inversed t model filters are proposed for realizing the sharpening spatial and the clamp filters. The T model filter[5] is a simplified form of the 3x3 convolution filter. The convolution filter efficiently reduces the complexity and the memory requirement of the line buffer.The input image is filtered by a sharpening and clamp filter . The t model filters require about two line buffers to store the values of the intermediate values and the data values of the T model filter. The T model filter reduce more computing resource and memory requipement of the sharpening and clamp filters.The Tmodel filter are combined to form a combined filterby this filter combination the memory requirement has been efficiently decreased

4. VLSI ARCHITECTURE

The proposed scaling algorithms consist of two combined filter and a simplified bilinear interpolator .The block diagram of the proposed architecture is as shown.

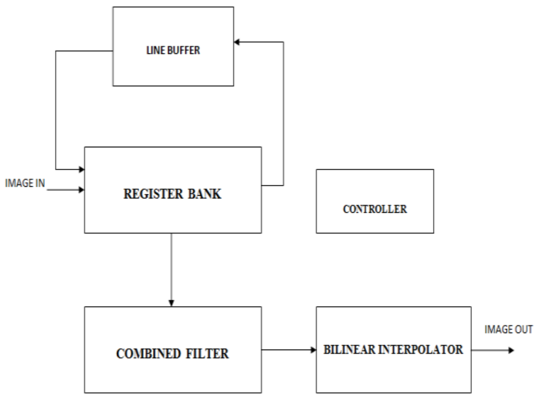


Figure 4:VLSI architecture of filter

5. REGISTER BANK

The register bank is designed with a one line memory buffer which is used to provide the pixel value to the immediate usage of the combined filter .the block diagram of the register bank. The register bank shown here when the shifting control signal is produced by the controller a new value will be read into a register and the value stored in the will be shifted to the next register or line buffer memory

6. COMBINED FILTER

The combined T model or inversed T model convolution function of the sharpening and the clamp filters are discussed. The block diagram shows the six staged pipelined architecture is as shown. The proposed shortens the delay path to improve the performance of the filter .The T model or the inversed T model filter contains three reconfigurable calculation unit ,three adders ,three subtracters ,three shifters .the symmetrical circuit as shown in figure is the inversed T filter. The combined filter and symmetrical circuit consist of one of multiplier adder and three reconfigurable calculation units.

7. BILINEAR INTERPOLATOR

In the previous discussion the bilinear interpolation is simplified as shown in (6).the stages 3,4,5, and 6 in figure shows the four stage pipelined architecture and two stage pipelined multiplier are used to shorten the delay path of the bilinear interpolator. The input values of P_(m,n) and P_(m,n-1) are obtained from the combined filter and symmetrical circuit. It also means that one multiplier and two adders can be successfully reduced by adding only one register. The controller is implemented by a finite state machine circuit. It produces control signals to control the timing and pipeline stages of the register bank combined filter and bilinear interpolator.

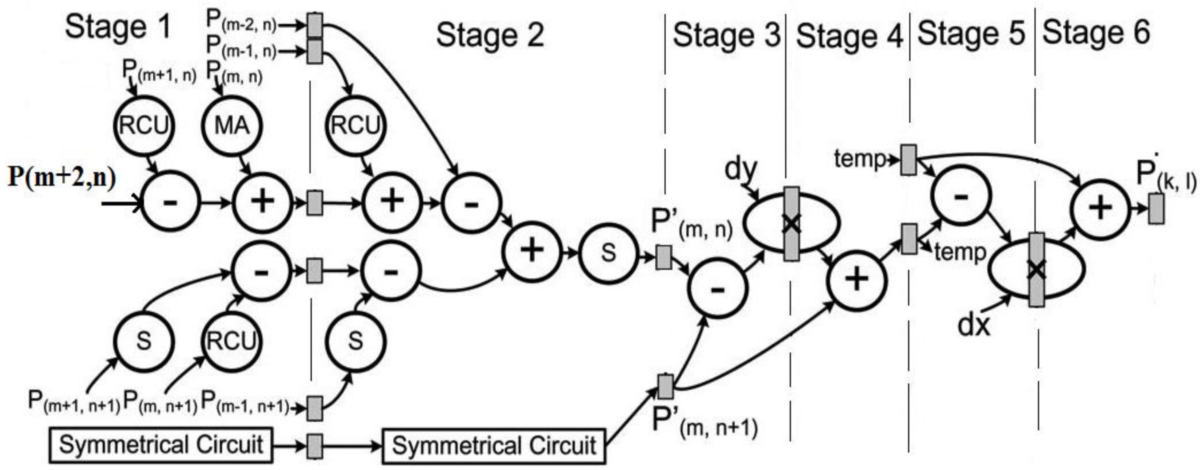


Figure 6: Computational scheduling of bilinear interpolator

8. RESULT AND DISCUSSION

The proposed architecture of the image scaling processor is simulated using modelsim and it is implemented using a Spartan FPGA. A test image of various sizes is passed and their outputs are observed. The quality of the scaled images can be found by peak signal to noise ratio. The peak signal to noise ratio is used to quantify the noise approximation of the original image. The test image is filtered by a fixed low pass filter which are then scaled up and scaled down to various sizes and their respective peak signal to noise ratio is calculated. The simulation results of the combined spatial and clamp filter is as shown below.

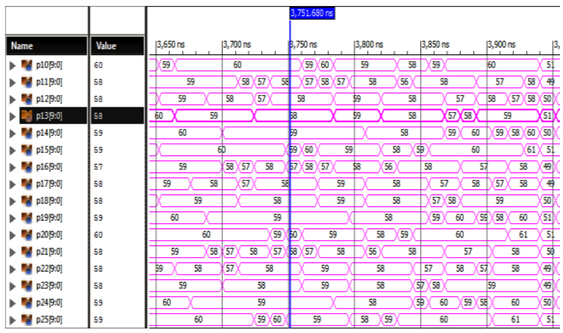


Fig 7: Simulation result of the combined spatial and sharp filter.

The output of the combined spatial and the sharpening filter are as shown.

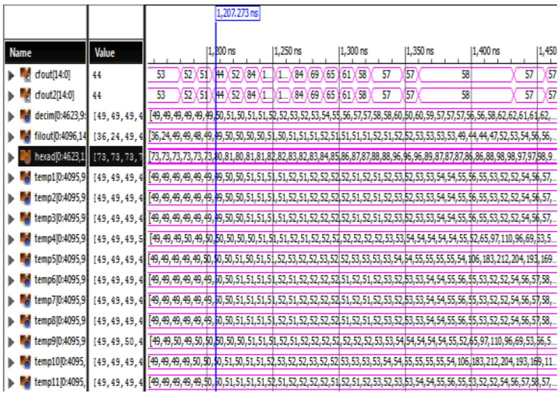


Figure 8: Simulation result of Image scaling processor

8.1 Combined Spatialsharpening-Smoothing Filtered Image

The image is smoothed and sharpened by using combination of clamp and sharpening spatial filter that has been shown in the following Fig. 8

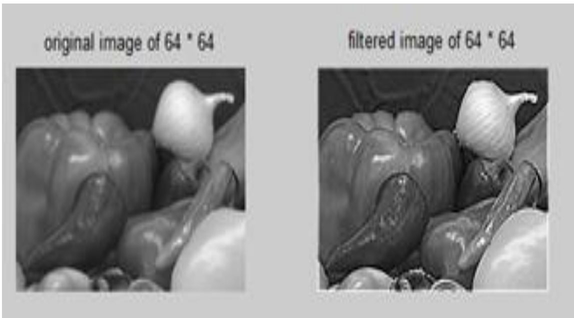
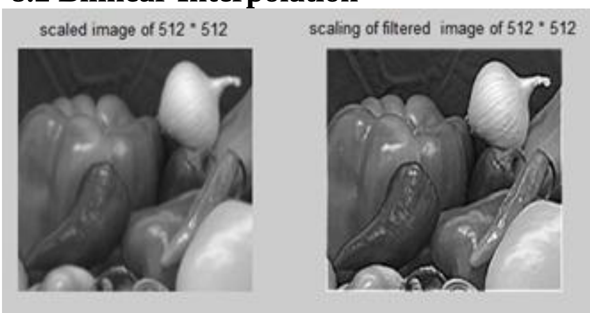


Fig. 8 Original and filtered image

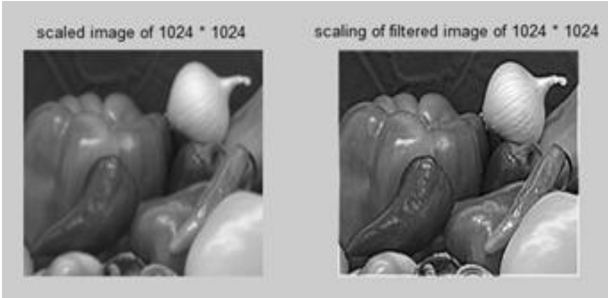
8.2 Bilinear Interpolation



(a) **(b)**

Fig. 9 Bilinear interpolation of 68×68 into 512×512 (a) Scaled original image (b) Scaled filtered image

The original 68×68 image is scaled to 512×512 without filtering is shown in Fig. 9 (a). The original 68×68 image is scaled to 512×512 with filtering is shown in Fig. 9 (b). The resultant image is sharpened when we use combined spatial sharpening-smoothing filter.



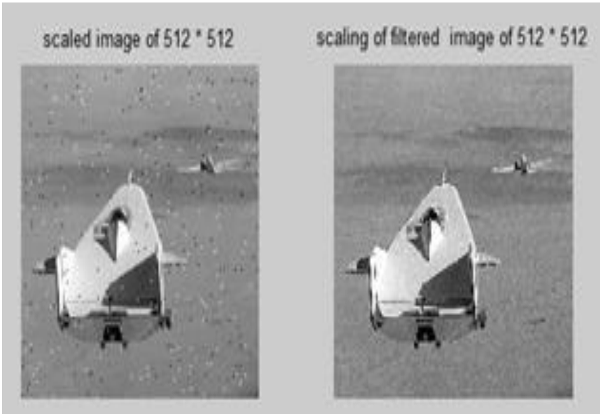
(a) **(b)**

Fig.10 Bilinear interpolation of 68 ×68 into 1024×1024 (a) Scaled original image (b) Scaled filtered image

Similarly the original image is scaled to 1024×1024 with and without filtering is shown in Fig 10.

8.3 Bilinear Interpolation for Noisy Image

The scaling of noisy image without filtering is shown in Fig. 11(a). In the image attained scaling is done but the noise is not removed. When the noisy image is scaled after filtering, the noise is removed. The output image thus obtained is shown in Fig. 11(b).



(a) **(b)**

Fig. 11 Bilinear interpolation of noisy image.(a) Scaled noisy image (b) Scaled noisy image with filter.

The image scaling processor designed and several images were passed and the power and the area of the processor is calculated. The power and area of the is shown in the table below.

Table 1: Power and area of the combined filter

	COMBINED FILTER
Power	4.86mw
Area (um^2)	10814

9. CONCLUSION

The proposed image scaling algorithm reduces the aliasing and the blurring of the image .The T model filters reduce the computational complexity in designing. The filter by combining the sharpening and the spatial filter to for the combined filter. The area and the power of the proposed filter is calculated. The proposed algorithm is of low complexity and occupies a less area.

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