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Adaptive Image Resizing using Edge Contrasting

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ABSTRACT

Zooming is an important image processing operation. It can be termed as the process of enlarging or magnifying the image to a given factor. Indiscriminate application of a function to an image in order to resample it, produces aliasing, edge blurring. So the objective is to reduce these artifacts.

This paper considers distinctive interpolation systems identified with versatile techniques with innate abilities to ensure sharp edges and subtleties. It is a versatile resampling calculation for zooming up pictures In this work, a versatile edge improvement procedure is proposed for two-dimensional (2-D) picture scaling application. The foreseen picture scaling calculation comprises of an edge identifier, bilinear interpolation and Sobel filter. The bilinear interpolation characterizes the power of the scaled pixel with the weighted normal of the four neighboring pixels, inserted pictures become smooth and loss of edge data. The versatile edge upgrade procedure is utilized to secure the edge includes successfully, to accomplish better picture quality and to dodge the edge data. The Sobel filter endeavors to decrease the commotion, in obscured and mutilated edges which is delivered by bilinear interpolation. A mathematical control and equipment sharing strategy are utilized to lessen registering asset of the bilinear interpolation. The examination shows that edges are very much safeguarded and interpolation artifacts (obscuring, jaggies) are decreased To contrast existing algorithms and proposed strategy calculation, we have taken original pictures and results for discussion. And we have gone to the choice that proposed calculation is superior to the current algorithms. We have looked at the images by two different ways – Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).

KEYWORDS: *Image resizing, Interpolation, Image blurring, Image zooming*

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I. INTRODUCTION

Image zooming is a the basic image processing mechanism. Methods like JPEG are normally a norm standard in spite of being a lossy methods, but exhibits has a good quality outcome. Zooming resizes images for seeing more detail, increasing resolution, making use of optics, various printing methods, or signal processing [4, 1]. Common applications of interpolation are viewing of online images ranging to magnification of satellite imagery. With the advent of digital photography, everybody expects better quality and control of digital images. Astral images from satellites are received at an extremely low transmission rate (about 40 bytes per second), making thereby making transmission of High Resolution data extremely difficult. In medical imaging, neurologists use zooming for brain tomography images. It can also be used to resize a video frame to fit the field of view thereby reducing blurring.

Conventional image zooming involves up sampling by zero insertion and then one dimensional filtering to interpolate the HR samples. The issue with this is that the frequency content of the HR image is the same as the Low Resolution (LR) image because the technique cannot introduce new information in the image. The absence of new HF content results in undesired image artifacts like blocking, staircase edges and blurring.

II. INTERPOLATION IN IMAGE ZOOMING

Image zooming is the most pivotal operation in image processing. Basically it is a mechanism to recover image from corrupted image to its original image. The restoration of corrupted images has many applications to repair images. Image interpolation is one such type of image restoration. Data is mentioned on a regular grid or on a but the program needs to compute values at random position on that grid [1].

Interpolation or resampling is an image processing method to increase or decrease the amount of pixels in a digital image [3]. It has uses ranging from computer graphics, rendering, editing, medical image reconstruction, to basic online image viewing.

Interpolation is achieved by assming the function using common functions like polynomial approximations. Inputs are evaluated at random positions in the input, not just confined to sample points. The very objective of interpolation is to produce acceptable images from multiple resolutions generated out of a single LR image.

The effective resolution is a complicated quantity to compute as it is dependent on perceptive human judgment.

The quality of image highly is based on interpolation technique. Image interpolation works two ways, and then approximates a pixel's color and intensity on the basis of surrounding pixels. The following example illustrates how resizing or enlargement works.

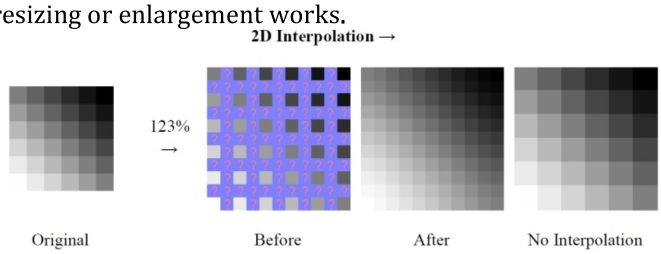


Fig 1 .Resizing / enlargement works

Magnification is enlarging but not physically. This enlargement is computed by a magnification factor In general, magnification can be classified as:

1. **Linear (transverse magnification):** For images, like images that are projected on a screen, size is to be treated like a linear dimension in millimeters or inches, for example.
2. **Angular magnification:** Placing the object close to the eye in a range lesser than its focussing range. Normally, the tangent of that angle is taken and this differs with angles larger than a few degrees only.

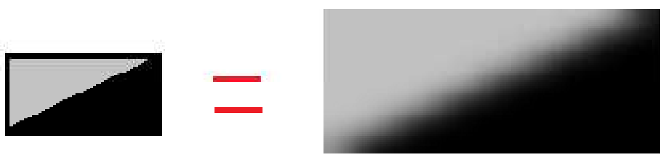
III. IMAGE INTERPOLATION TECHNIQUES

Generic interpolation algorithms can be classified as: adaptive and non adaptive. Adaptive methods depend on content of interpolation, while non adaptive methods treat each pixel uniformly.

3.1. Non-Adaptive Algorithms

Non adaptive interpolation methods interpolate by static method for all pixels and have the advantage of easy and low calculation cost [2]. Depending on the computational complexity, these methods use 0 to 256 adjoining pixels while interpolation. The process achieves even more accuracy with more adjacent pixels they included, however at the cost of an extended processing time. These algorithms are used to distort as well as resize an image. The zoomed image of Figure 2.1(a) using non adaptive algorithm is shown in Figure 2.1(b). Non adaptive algorithms are:

1. Nearest Neighbor
2. Bilinear
3. Bicubic Smoother
4. Bicubic
5. Bicubic Sharper
6. Lanczos
7. Bilinear blur



(a) Test Image (b) Bilinear b/w Blur
Fig 2: Enlarged Image using Non-Adaptive Algorithm

3.2. Adaptive Algorithms:

Adaptive interpolation computes corrupt or lost pixel values from surrounding pixels and can improve the image from non adaptive algorithm [21]. However, it involves calculations. Many of these apply a pixel to pixel wise version of their algorithm on detecting the presence of an edge with an objective to minimize unseen interpolation effects in regions where they are most visible. The algorithms optimize the error free details in zoomed photos, so some cannot be used to distort or rotate an image. The zoomed image of Figure 2.2(a) using adaptive algorithm is shown in Figure 2.2(b). Adaptive algorithms are:

1. Genuine Fractals
2. Photo Zoom
3. Smart Edge

3.3. Interpolation Methods

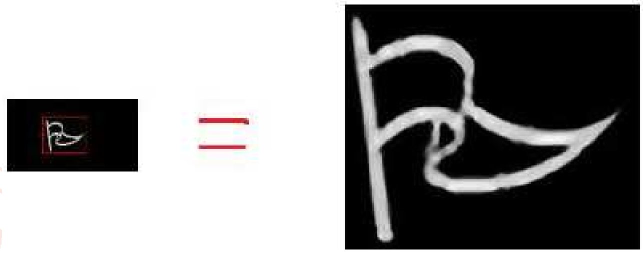


Figure 3: Enlarged Image using Adaptive Algorithm.

IV. VLSI ARCHITECTURES FOR IMAGE INTERPOLATION

VLSI architectures are materialised using FPGA or application specific integrated circuits commonly termed as ASICS. FPGAs are reconfigurable computing systems with high performance and low costs. But ASIC's are not reconfigurable. Modern FPGA platforms consist of millions of gates, up to 1ghz clock frequency, Large on Chip memory and fast IOs [24]. FPGAs see a lot of applications in real time implementation of image processing methods like motion detection, image enhancement, image correlation, and image compression. In this paper, different hardware architectures of interpolation methods are discussed and their performance analysed.

4.1. Digital Image Scaling Algorithm

Andreadis and Amantiadis suggested an image interpolation mechanism for both monchrome and rgb images of varied resolutions with any scaling factor [25]. The algorithm uses a mask of maximum four pixels and computes the luminosity values pixel to pixel combining area covered by mask from each source pixel and the luminosity difference between the source pixels. This interpolation works on linear area domain with continuous area filtering. It can perform upscale and downscale processes at the same time for fast and real time implementation. The system has been implemented on Quartus II FPGA with an operating frequency of 55MHz

This hardware uses 20 additions and 13 multiplications. The RMSE obtained through this comparatively much lesser than by other interpolations like nearest neighbour, bilinear, and winscale.

4.2. Winscale Image Interpolation

Image scaling employing winscale [26] is proposed by Kim. The objective of algorithm is to reduce the computational complexity by minimising number of operations per pixel. This algorithm can perform both scale up and scale down transform using an area pixel model rather than a point pixel model. Four maximum pixels from the original image are used to calculate one pixel of a scaled image to provide low complexity. Also, this provides enhanced quality in fine edge and smoothness. Winscale has been implemented in FPGA with liquid crystal display panel. With good scaling property, Winscale has very low computational complexity. Also it protects the edges of an image and also manages streaming data with optimised levels of memory requirements.. Thereby enabling image interpolation to be achieved by four line buffers replacing up down ratio

V. PROPOSED METHODOLOGY

Fig.1 shows the block diagram of an enhanced adaptive edge based scalar architecture consisting of a sobel filter, edge detector, and bilinear interpolator. Here, an RGB image is converted into monochrome using MATLAB. Now monochrome image is converted into binary image. This image is then resized for it to be converted into a text file. Then the binary image (Text file) is stored into the RAM. Text File is read from memory Bank. Memory bank is used as the input to the sobel filter and edge detector. Post simulation is done by Modelsim.

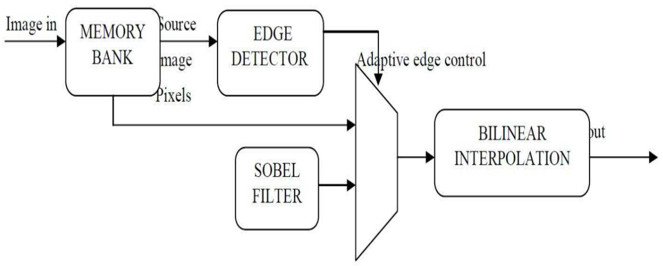


Fig 4 Block diagram of adaptive edge enhanced scalar architecture

5.1. Bilinear Interpolation

Bilinear interpolation [2], [32], [37] is basically a resampling method, using the four nearest adjoining pixel values, followed by new pixel values calculation using weighted average of the four pixels on the basis of distance. Linear interpolations are performed horizontally and then one more linear interpolation is performed vertically interpolation can be done by four line buffers instead of updown ratio.

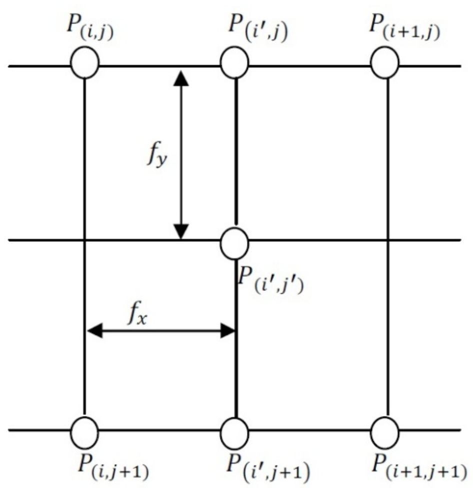


Fig.5 Bilinear Interpolation

The interim pixels are $P_{i',j}$, $P_{i',j+1}$ have been created as a result of linear interpolation in horizontal direction and is computed as

$$P_{i',j} = (1 - f_x)\, P_{i\ \ ,j} + f_x\, P_{i+1\ \ ,j}$$
$$P_{i',j+1} = (1 - f_x)\, P_{i\ \ ,j+1} + f_x\, P_{i+1\ \ ,j+1}$$

With f_x being the scale parameter in horizontal directio. After interpolation in this direction, the values of intermediate pixels $P_{i',j}, P_{i',j+1}$ are computed with the resulting output pixel $P_{i',j'}$ being obtained by linear interpolation in vertical direction and is calculated as

$$P_{i',j'} = (1 - f_x)\, P_{i\ \ ,j} + f_x\, P_{i+1\ \ ,j}\ \mathrm{X}\quad (1 - f_y)\, P_{i\ \ ,j+1} + f_x\, P_{i+1\ \ ,j+1}\, \mathrm{X}\, f_y$$

With f_y being the the scale parameter in vertical direction. The fx and f_y are called zooming ratios for x and y direction. Bilinear interpolation has been used predomimantly in VLSI implementation owing to its low complexity. Post completion of bilinear interpolation, edges become blurry and produce aliasing effect.

5.2. Edge-Detecting Technique:

Here, the edge detecting technique uses a sigmoidal edge detecting method [38] with the interpolated pixel P_k being calculated using four closest pixels $p_{i-1}, p_i, p_{i+1}, p_{i+2}$ $placed\ at\ i-1, i, i+1, i+2\ respectively$

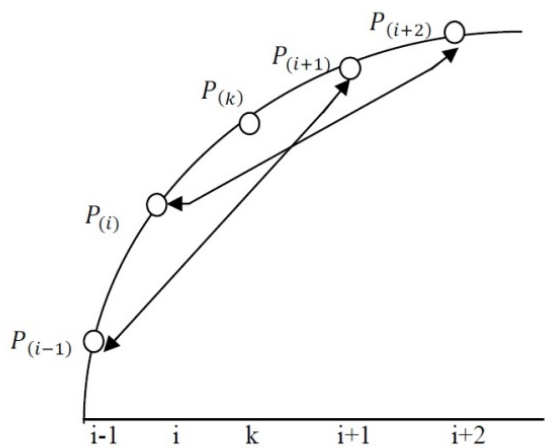


Fig 6 Local characteristics of the data in the neighborhood of k

E= |P(i + 1) – P(i – 1)| –|P(i + 2) – P(i)|.

1. E=0, symmetry of edges on the right side and left side.
2. E>0, showing more homogeneity for edges on the right side.
3. E<0, showing more homogenity of edges on the left side.

This edge detecting method used to obtain the local characteristics of edges. The interpolated images become smooth and there is a loss of edge information. To protect edge information using an adaptive edge enhancement technique. For example, the edge detector is used to search edges on the left side, if more homogeneous of the left side (E<0). To exclude the loss of edge information after bilinear interpolation, right side of two pixels is adaptively enhanced by the Sobel filter

5.3. Sobel Filter

The principal use of Sobel filter is for edge detection. Sobel filter diminishes blurring and aliasing artifacts. By using two kernels of 3×3 sizes for estimating the gradient in the horizontal as well as in vertical direction. The kernels are then convolved with the image with algorithm calculating image intensity gradient pointwise, giving directions to accentuate the image intensity at points ranging from light to dark. Edge areas significantly deduce strong intensity contrasts which are darker or brighter.

-1	0	+1
-2	0	+2
-1	0	+1

H_x

+1	+2	+1
0	0	0
-1	-2	-1

H_y

Fig.7. Sobel operator

To measure gradient magnitude is given by

$$|H| = \sqrt{H_x^2 + H_y^2}$$

5.4. Proposed VLSI Architecture:

The advantage of Scaling method is that it requires low computational complexity and improves image quality. Figures are showing the structure of sobel filter, edge detector and bilinear interpolator.

5.5. Sobel Filter Design

The Sobel filter is a first order edge detection operator which uses the two orientations which are 0°and 90° convolution kernels. Two masks are used which after being convolved with original image produce gradient approximations. The absolute values of gradient *Hx* and Hy for pixel $P_{(i+1,\,j+1)}$ is given by

$$|H_x| = |(P_{(i,j+2)} - P_{(i,j)}) + 2 * (P_{(i+1,j+2)}\, P_{(i+1,j)}) + (P_{(i+2,j+2)} - P_{(i+2,j)})|$$

$$|H_y| = |(P_{(i+2,j)} - P_{(i,j)}) + 2 * (P_{(i+1,j+2)}\, P_{(i+1,j)}) + (P_{(i+2,j+2)} - P_{(i+2,j)})|$$

The gradient values Hx and Hy are calculated according to Eq. 5 and Eq.6. Fig. 5 is showing pipelined structure of the Sobel filter and edge detector, with the Upper part showing the Sobel filter's pipeline architecture . The processing module is employing additions, multiplication, and subtractions. Since multiplication is costly in hardware, hence it is accomplished by the shift operation. The architecture for computing both gradients is shown in Fig.5

5.6. Edge Detector

The local features of edges are calculated by using Eq.4. Fig.5. shows the bottom part of the stages is edge detector that consists of one comparator, three subtractors and two registers. The subtractor unit uses two inputs and generates their absolute value of difference. The comparator then produces control signal for the multiplexer. The control signal is based on the evaluating parameter E is greater than 0, less than 0, and equal to 0.

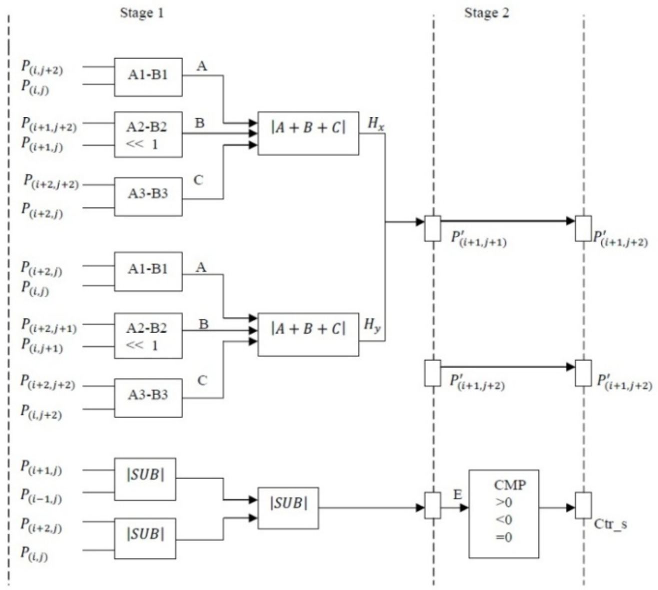


Fig.4.5. Architecture of sobel filter and edge detector

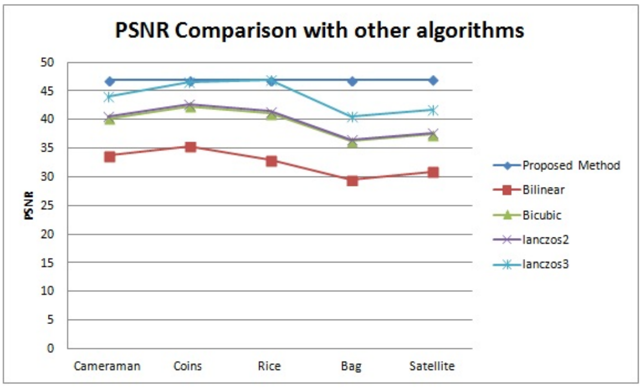
VI. RESULTS

6.1. Performance metrics:

Apart from the visual quality assessment of images through naked eye comparison, several quantitative methods are also used to evaluate the outputs of the proposed algorithm. Quantitative Comparisons We uses two different quantitative measurements on images from the standard Matlab database. The measurements used in the thesis are MSE and PSNR.

Mean Square Error: The Mean Squared Error defines the cumulative squared error between the refined image and the original image. The low value of the MSE is considered as low error. The MSE defined as

$$\text{MSE} = \sum_{i=1}^{x} \sum_{j=1}^{y} \frac{(|A_{ij} - B_{ij}|)^2}{x * y}$$



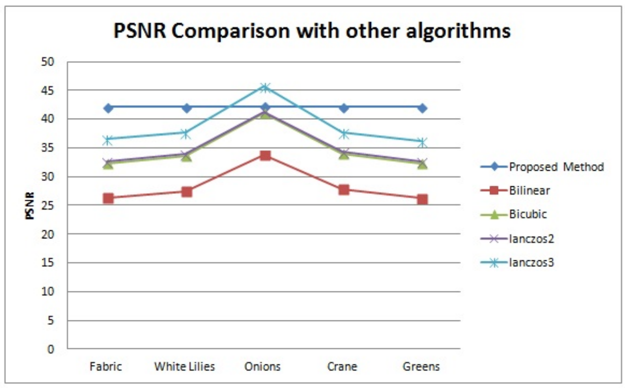


Fig 5.9 PSNR Comparison with other algorithms. The proposed algorithm shows a distinct edge above other algorithms in almost all RGB cases

Output Image

Interpolated Image

128x128 Output for the Gantry Crane Image Interpolation
MSE=3.9997, PSNR=42.1106 for the Proposed Method

Interpolated image using Bilinear
MSE=105.8125, PSNR=27.8854

Interpolated Image

Interpolated Image

Interpolated image using Bicubic Interpolation Interpolation
MSE=26.1589, PSNR=33.9546

Interpolated image using lanczos2
MSE=24.233, PSNR=34.2867

Interpolated Image

Interpolated image using lanczos3 Interpolation
MSE= 10.908, PSNR=37.7534

Output Image

Interpolated Image

128x128 Output for the Cameraman GrayScale Image Interpolation
For proposed method
MSE=1.333, PSNR=46.8814

Interpolated image using lanczos3
MSE= 2.5351, PSNR=44.0909

Interpolated Image

Interpolated Image

Interpolated image using lanczos2 Interpolation Interpolation
MSE= 5.8264, PSNR=40.4768

Interpolated image using bilinear
MSE= 27.8471, PSNR=33.683

Interpolated Image

Interpolated image using bicubic Interpolation
MSE=6.2156 , PSNR=40.196

Fig Comparison of output RGB Images for Proposed method with the alternate algorithms on the basis of PSNR and MSE metrics

TABLE 5.1

PSNR Comparisons of Proposed Method with Alternate Algorithms using RGB Images

Database Image	Bilinear	Bicubic	lanczos2	lanczos3	Proposed Method
Fabric	26.2258	32.2975	32.6233	36.4998	42.1179
White Lilies	27.3678	33.67	33.9654	37.7516	42.1102
Onions	33.686	41.0328	41.3062	45.6405	42.2498
Crane	27.8854	33.9546	34.2867	37.7534	42.1106
Greens	26.2157	32.3145	32.6284	36.2774	42.1118

TABLE 5.2

PSNR Comparisons of Proposed Method with Alternate Algorithms using Grayscale Images

Database Image	Bilinear	Bicubic	lanczos2	lanczos3	Proposed Method
Cameraman	33.683	40.196	40.4768	44.0909	46.8814
Satellite	36.7798	43.5427	43.8603	47.9113	46.9029
Rice	32.8782	41.0577	41.3967	46.8492	46.8814
Coins	35.3476	42.2494	42.5969	46.542	46.8814
Bag	29.4608	36.1894	36.5305	40.4612	46.8814

TABLE 5.3

MSE Comparisons of Proposed Method with Alternate Algorithms using RGB Images

Database Image	Bilinear	Bicubic	lanczos2	lanczos3	Proposed Method
Fabric	155.0618	38.3114	35.5426	14.5579	3.9929
White Lilies	119.2067	27.9306	26.0941	10.9124	4
Onions	27.828	5.1263	4.8135	1.7743	3.8735
Crane	105.8125	26.1589	24.233	10.908	3.9997
Greens	155.4202	38.162	35.5014	15.3228	3.9985

TABLE 5.4

MSE Comparisons of Proposed Method with Alternate Algorithms using Grayscale Images

Database Image	Bilinear	Bicubic	lanczos2	lanczos3	Proposed Method
Cameraman	27.8471	6.2156	5.8264	2.5351	1.3333
Satellite	52.7477	11.9794	11.1873	4.4417	1.3315
Rice	33.5168	5.0969	4.7142	1.3433	1.3333
Coins	18.9811	3.8739	3.5759	1.4417	1.3333
Bag	73.6208	15.6366	14.4553	5.8474	1.3333

Where x and y represents the number of rows and columns of the pixels of the original image.

Peak Signal to Noise Ratio: PSNR is an approximation to human perception of reconstruction quality. More PSNR is a reflection of reconstruction of higher quality. PSNR is defined as

$$PSNR= 10\ log_{10}\left(\frac{R^2}{MSE}\right)$$

VII. CONCLUSION

The proposed algorithm has been tested on a Database of more than 100 images and has been found to perform with a far superior performance in terms of PSNR and MSE values. There have been only a few instances of use of Lanczos3 interpolation filter where the algorithm has shown marginal underperformance when tested on Matlab Built in, which is not a realtime implementable algorithm on VLSI architecture. On all the rest of the images, our proposed hardware implementable algorithm has shown a stark superiority in performance as compared to other Matlab built in implementations of the Algorithm.

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