A Parallel model for Noise reduction of images using smoothing filters and Image averaging

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Abstract

Image Enhancement is the art of examining images for identifying objects and judging their significance. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. Smoothing is often used to reduce noise within an image or to produce a less pixilated image. This paper proposes a new idea for enhancement of an image using smoothing filters and the image noise is mostly unwanted and manifested in the pixels of an image and the main application of image averaging is noise removal. In this paper, we deal with image enhancement using smoothing filters with the help of parallel model in order to improve the quality of the image and as well as to help to solve various complex image processing tasks in the future. This paper focuses on an approach which tries to combine the advantages of the various smoothing filters techniques and proposes a parallel model. This parallel model can be implemented using various models, considering available resources with the server. After the review of earlier publications on this topic available and a comparative study of their advantages and disadvantages a parallel model that is simpler to implement and efficient has been proposed in this work.

Keywords: Image enhancement, parallel model smoothing filters, Image averaging function, Noise reduction.

1. Introduction

Image processing [6] modifies pictures to improve them (enhancement, restoration), extract information (analysis, recognition), and change their structure (composition, image editing). Images can be processed by optical, photographic, and electronic means, but image processing using digital computers is the most common method because digital Methods are fast, flexible, and precise. Image enhancement improves the quality (clarity) of images for human viewing.

Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. For example, an image might be taken of an endothelial cell, which might be of low contrast and somewhat blurred. Reducing the noise and blurring and increasing the contrast range could enhance the image. The original image might have areas of very high and very low intensity, which mask details. An adaptive Enhancement algorithm reveals these details. Adaptive algorithms adjust their operation based on the image information (pixels) being processed. In this case the mean intensity, contrast, and sharpness (amount of blur removal) could be adjusted based on the pixel intensity statistics in various areas of the image. These edge enhancement techniques falls under two categories smoothening filters and sharpening filters. Smoothing filters are used for blurring and for noise reduction. Blurring is used in preprocessing steps, such as removal of small details from an image prior to object extraction, and bridging of small gaps in lines or curves. Noise reduction can be accomplished by blurring with a linear filter [2] and also by nonlinear filtering such as mean, median, mode, circular, pyramidal and cone filters. Sharpening filters are used to highlight fine detail in an image or to enhance detail that has been blurred. These filters include Laplacian, Sobel, Prewitt and Robert filters which are widely used in applications but because of their results of complexity and image quality, smoothening filters are used which involves simple subtractive smoothened image concept which reduces complexity and makes the images look sharper than they really are.

2. DIFFERENT TYPES OF SMOOTHING FILTERS

2.1 What is Image enhancement?

Image Enhancement [1] is a digital image processing [7] filter that is used to make pictures look artificially sharper than they really are. The key word here is *looking* sharper, because the picture isn't really any more detailed than before. The human eye is simply *tricked* into thinking the picture is sharper.

2.2 Smoothing filters:

2.2.1 Mean filter

The mean filter [8] is a simple sliding-window spatial filter that replaces the center value in the window with the average (mean) of all the pixel values in the window. The window, or kernel, is usually square but can be any shape. An example of mean filtering of a single 3x3 window of values is shown below.

unfiltered values		
5	3	6
2	1	9
8	4	7

5 + 3 + 6 + 2 + 1 + 9 + 8 + 4 + 7 = 45
45 / 9 = 5

mean filtered		
*	*	*
*	5	*
*	*	*

Center value (previously 1) is replaced by the mean of all nine values (5).

2.2.2 Median filter

The median filter [4] is also a sliding-window spatial filter, but it replaces the center value in the window with the median of all the pixel values in the window. As for the mean filter, the kernel is usually square but can be any shape. An example of median filtering of a single 3x3 window of values is shown below.

unfiltered values		
6	2	0
3	97	4
19	3	10

In order:
0, 2, 3, 3, **4**, 6, 10, 15, 97

median filtered		
*	*	*
*	4	*
*	*	*

Center value (previously 97) is replaced by the median of all nine values (4).

2.2.3 Mode Filter:

The mode filter replaces the pixel at the center of the mask by the mode of all the pixel values in the mask. The mode value is nothing but the maximally repeated value in the mask.

2.2.4 Circular Filter:

In this filter, we will convolute the image the mask provided [1, 3]. This filter is slightly different from the mean filter. The filter is shown below

$$\frac{1}{21}\begin{bmatrix} 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Circular Filter Mask

2.2.5 Triangular filter:

In this, the output image is based on a local averaging of the input filter, where the values with in the filter support have differing weights. In general, the filter can be seen as the convolution of two identical uniform filters either mean or circular and this has the direct consequence for computational complexity. Transfer functions of these filters do not have the negative values and hence it will not exhibit the phase reversal. There are two filters of this kind, namely Pyramidal filter and Cone filter. The convolution masks for these are shown below.

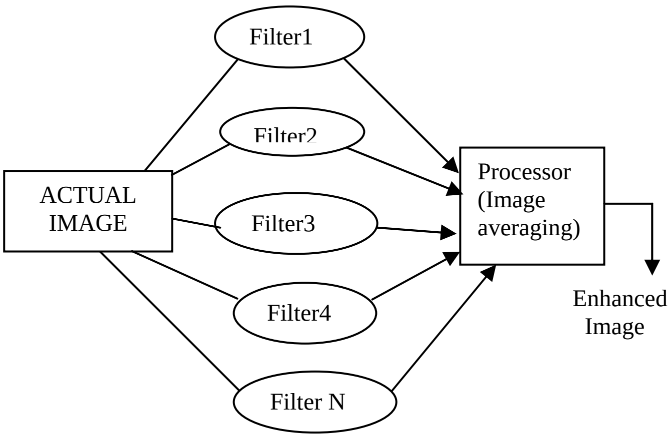
$$\frac{1}{81}\begin{bmatrix} 1 & 2 & 3 & 2 & 1 \\ 2 & 4 & 6 & 4 & 2 \\ 3 & 6 & 9 & 6 & 3 \\ 2 & 4 & 6 & 4 & 2 \\ 1 & 2 & 3 & 2 & 1 \end{bmatrix} \qquad \frac{1}{25}\begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 2 & 2 & 2 & 0 \\ 1 & 2 & 5 & 2 & 1 \\ 0 & 2 & 2 & 2 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

Cone Filter Mask Pyramidal Filter Mask

3. Implementation of parallel model

This model uses a parallel structure. The filters are arranged in parallel and the results are obtained independent of each other which are the passed to an array. This array is then sent to the processor where in the image enhancement mean is generated

Smoothing filters



Parallel Model

The advantage of this model is that it is time efficient as the calculation of each filter is done in parallel.

However the limitations are:

1. The system requires all the filters to be available at the same time.
2. The system has to wait for the result of each independent filter to calculate the mean

Total time taken =Max time of slowest filter + Processing time

The available free time of the filters waiting for completion of processing of slowest filter can be used to update image which can improve the time efficiency.

4. FUNCTION DONE BY THE PROCESSOR

Image Averaging [10]

Suppose noise $\eta(r, c)$ is a zero mean pair wise uncorrelated. Then a set of n noisy images
$\{g_i(r, c)\}$ can be given by
$g_i(r, c) = f(r, c) + \eta_i(r, c)$
Also suppose that $\eta_i(r, c)$ follows the same distribution for all i, $\sigma\eta 2(r, c)$ be its variance. The assumptions are approximately valid if we consider, say, transmission channel noise only. That means if an image f(r, c) is transmitted n times over some communication channel we may receive a set of noisy images {g1(r, c),
$g_2(r, c), \ldots, g_n(r, c)\}$ at the receiver end. The objective is to recover f(r, c) from the given set {gi(r, c)}. By averaging n such images we get
$g(r,c) = (1/n) \sum^{n}_{i=0} g_i(r,c) = f(r,c) + (1/n) \sum^{n}_{i=0} \eta_i(r,c) = f(r,c) + \eta(r,c)$
For all r and c. Since noise has zero mean, for large n, g(r, c) approaches f(r, c) and
$_{\sigma}{}^{2}\, \eta(r, c) = {}_{\sigma}{}^{2}\, g(r, c) \quad = (1/n)\, {}_{\sigma}{}^{2}\, \eta(r, c)$
tends to zero as n increases.

APPLICATION OF IMAGE AVERAGING

The main application of image averaging is noise removal. Image noise [13] is mostly unwanted and manifested in the pixels of an image. It is inherent to digital cameras and is generated, in part, by heat and low light conditions, and is often prominent in long exposures and photographs taken at high ISO sensitivity. Its effect is analogous to film grain.

When images of an unchanging scene are corrupted by random noise, a sequence of these images can be averaged together in order to reduce the effects of the noise. This works because noise perturbs pixel grey levels, and a positive perturbation of a given magnitude tends to be just as likely as a negative perturbation of the same magnitude. Hence there is a tendency for these 'errors' in pixel grey level to cancel each other out to an increasing degree, as the number of averaged images increases.

Algorithm:

Step1: Read Input file as Noised Image

Step2: Apply Parallel model

Give Noised Image as Input to all Smoothing Filters in parallel

Step3: Save outputs of Filters that is filtered images

Step4: Now apply Image Averaging method to all these filtered Images

Step5: Average takes the sum of pixel values from the specified number of scan and use arithmetic mean as the final value in the image.

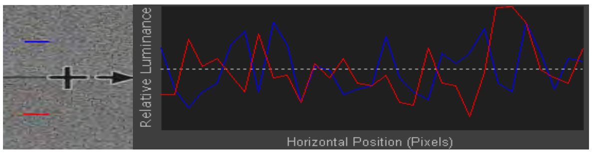
Step6: Finally we get average of all filtered images that is average image

Step7: Show Output Image

5. NOISE REDUCTION BY IMAGE AVERAGING

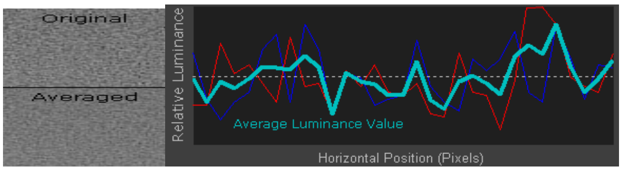
CONCEPT:

Image averaging works on the assumption that the noise in your image is truly random. This way, random fluctuations above and below actual image data will gradually even out as one average more and more images. If you were to take two shots of a smooth gray patch, using the same camera settings and under identical conditions (temperature, lighting, etc.), then you would obtain images similar to those shown on the left.



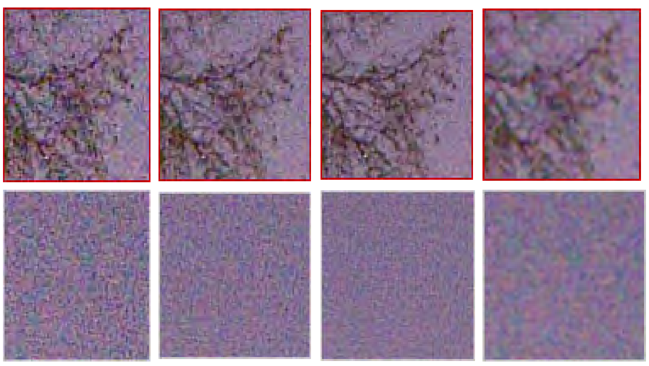
The above plot represents luminance fluctuations along thin blue and red strips of pixels in the top and bottom images, respectively. The dashed horizontal line represents the average, or what this plot look like if there were zero noise. Note how

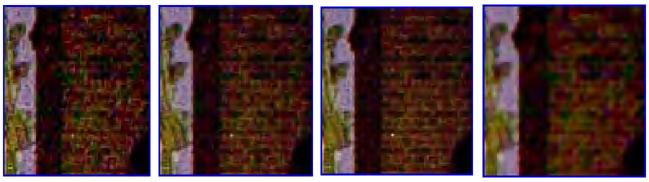
each of the red and blue lines uniquely fluctuates above and below the dashed line. If we were to take the pixel value at each location along this line, and average it with value for the pixel in the same location for the other image, then the luminance variation would be reduced as follows:



Even though the average of the two still fluctuates above and below the mean, the maximum deviation is greatly reduced. Visually, this has the affect of making the patch to the left appear smoother. Two averaged images usually produce noise comparable to an ISO setting which is half as sensitive, so two averaged images taken at ISO 400 are comparable to one image taken at ISO 200, and so on. In general, magnitude of noise fluctuation drops by the square root of the number of images averaged, so you need to average 4 images in order to cut the magnitude in half.

Original	2 Images average	4 Images average	Median Filter





Note how averaging both reduces noise and brings out the detail for each region. Noise reduction programs such as Neat Image [12] are the best available arsenal against noise, and so this is used as the benchmark in the comparison:

6. Conclusion & Future Work

Smoothing filters provide better image quality and is also quite simple in computation, which is highly desired in many real-world applications. The Computational complexity is decreased from O (n^2) to O(n) using smoothening filters. Using the smoothening filters the images look sharper than really they are. In terms of space domain for a kxk Traditional filter, 2D convolution requires K^2 operations per pixel where as the smoothening filters takes only k operations per pixel..

This new method of parallel model is compared against all the smoothening filters presented in the project and the parallel model is analyzed and implemented by filters to improve the computation times. Image noise is mostly unwanted and manifested in the pixels of an image and main application of image averaging is noise removal

The proposed parallel model and image averaging method is applied to grayscale images. This procedure allows us to compare and evaluate the filtered image against the original one. The Image average method is applied obtain the best noise reduction of image which provides the best results for displaying the enhanced output image.

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Although numerous image enhancement approaches have been proposed in different real-world applications, in order to examine the performance on edge enhancement against noise and several other factors of an image we will continue our work with Artificial Bee colony (ABC), Artificial Immune System (AIS), Ant Colony Optimization technique (ACO) and fuzzy logic

There are still many interesting research issues related to the extensions of image noise reduction.

Genetic-neuro-fuzzy technique is very effective in speckle noise reduction as well as detail preserving even in the presence of highly noise corrupted data, and it works significantly better than other well-known conventional methods in the literature.

New alternative noise reduction method for color images that were corrupted with additive Gaussian noise.

New alternative noise reduction method for images that is Fuzzy Image Filtering

7. Reference List

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