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Adaptive Smoothing Technique for Remotely Sensed Images Enhancement

I. J. Muhsin
Remote sensing unit, College of Science, University of Baghdad

Abstract:
Spatial and frequency domain techniques have been adopted in this search. mean value filter, median filter, gaussian filter. And adaptive technique consists of duplicated two filters (median and gaussian) to enhance the noisy image. Different block size of the filter as well as the sholding value have been tried to perform the enhancement process.

طريقة تنعيم مطورة لتحسين الصور الفضائية

إسراء جميل محسن
وحدة التحسس النائي/ كلية العلوم/ جامعة بغداد

الخلاصة:
استخدمت في هذا البحث تقنيات الترخيم في كلا المجالين الترددي والحيزي، التي تضم مرشحات التنعيم مثل مرشح معدل القيمة، مرشح متوسط القيمة ،المرشح الكاوسي، وكذلك تم استخدام مرشح مركب من المرشح المتوسط والمرشح الكاوسي لتحسين الصور المتردية. كما تم اخذ قيم مختلفة من حجم النافذة وقيمة العتبة لإنجاز عملية التحسين.

Introduction

Smoothing is a process by which data points are averaged with their neighbours in a series, such as a time series, or image. This (usually) has the effect of blurring the sharp edges in the smoothed data. Smoothing is sometimes referred to as filtering, because smoothing has the effect of suppressing high frequency signal and enhancing low frequency signal. There are many different methods of smoothing, but here we discuss smoothing with mean value, median, and Gaussian.

In the literature, enhancement techniques are classified into three different approaches [1]. The first referred as a point-value-dependent-method, modifies pixel values independently of its neighbor pixel's values. Histogram stretching and histogram equalization techniques are examples of this enhancement method. The second types of enhancement are those modifying pixel values depending on their neighborhood; averaging, median and arithmetic filters are examples of this type [2]. The third enhancement type included the global methods. In these methods, the whole pixel's values within the image or sub image are taken into consideration [3]. The mentioned classes of enhancement are, in fact, classified as spatially filtration process. Other enhancement methods, classified as frequency domain or transformation techniques are, also, existed. Frequency domain methods can become neighborhood dependent methods, by performing the transform on small image blocks instead of the entire image.

In this search we use many techniques to smooth and enhance the noisy images. One of these technique depend on spatial domain such as and the other depend on the frequency domain such as (mean, median, Gaussian ..etc.) and adaptive technique have been adopted in this paper consist of using duplicated filters depend on interface two filters (median and Gaussian) to enhance the degradation image. In practice, the degradation function is, often, unknown and should be estimated [4].

Generally, the degradation process, in the spatial domain, is modeled as:

$$g(x, y) = h(x, y) \otimes f(x, y) + n(x, y) \quad (1)$$

Where: f (x, y) = the input signal,

h (x, y) = the point spread function (psf), and n (x, y) = the general noise distortion function.

The psf can be either space-variant (i.e. non-isoplantic), or space-invariant (i.e. isoplantic) functions. In the first, the form of the psf changes its shape as well as its position, while the second distributed uniformly over the whole image regions [4]. The frequency domain model of equation (1) is given by:

$$G(u, v) = H(u, v) \,.\, F(u, v) + N(u, v) \quad (2)$$

Where: G (u, v) = Fourier transform of the degraded image.

H (u, v) = Fourier transform of the degradation function.

F (u, v) = Fourier transform of the original image.

N (u, v) = Fourier transform of the additive noise function.

Practically, image noises may be presented in two different forms; i.e.

1. Multiplied form of noise, modeled as [Ali:88]:

$$g(x, y) = (h(x, y) \otimes f(x, y)).n(x,y) \quad (3)$$

2. Additive form of noise, given by equation (1).

Typically, manipulating images suffering from multiplicative noise is not an easy task and, usually, transformed into additive form by taking the logarithmic values of the degraded image [1].

Mean Value Smoothing

Image can contain random noise superimposed on the pixel brightness values owing to noise generated in the transducers which acquire the image data , systematic quantization noise in the signal digitizing electronics and noise added to the video signal during transmission. This will show as a speckled "salt and pepper" pattern on the image in regions of homogeneity; it can be removed by the process of low pass filtering or smoothing, unfortunately usually at the expense of some high frequency information in the image. To smooth an image is used with entries:

$$t(m, n) = 1/_{MN} \qquad \text{forall } m, n \qquad (4)$$

so that the template response is a simple average of the pixel brightness values currently within the template, viz

$$r(i, j) = \frac{1}{MN} \sum_{m=1}^{M} \sum_{n=1}^{N} \phi(m, n) \qquad (5)$$

The pixel at the centre of the template is thus represented by the average brightness level in a neighborhood defined by the template dimensions. This is an intuitively obvious template for smoothing and is equivalent to using running averages for smoothing time series information.

It is evident that high frequency information such as edges will also be averaged and lost. This loss of high frequency detail can be circumvented somewhat if a threshold is applied to the template response in the following manner.

Let:

$$e(i,j) = \frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}\phi(i,j) \qquad (6)$$

then

$$\begin{aligned} r(i,j) &= e(i,j) \quad \text{if} \quad |\phi(i,j) - e(i,j)| < T \\ &= e(i,j) \quad \text{otherwise} \end{aligned} \qquad (7)$$

where T is a prespecified threshold. T could be determined a priori based upon knowledge of or an estimate of scene signal to noise ratio [5].

Elason and MeEwan [6] recommend choosing the threshold as a multiple of the standard deviation of brightness within the template window. This provides better noise removal in homogeneous regions while allowing better preservation of edges and other valid high spatial frequency detail.

A simple illustration of image smoothing by averaging over a template , both with and without the application of a threshold, is given in Fig. (1) For clarity this is based upon a hypothetical one dimensional image, or alternatively a single line of image data, with which a 3×1 template is used. In this manner the actual numerical modification of pixel brightness values can be observed.

In principle, templates of any shape and size can be used. Larger templates give more smoothing (and greater loss of high frequency detail) whereas horizontal rectangular templates will smooth horizontal noise but leave noise and high frequency detail in the vertical direction relatively unaffected by comparison.

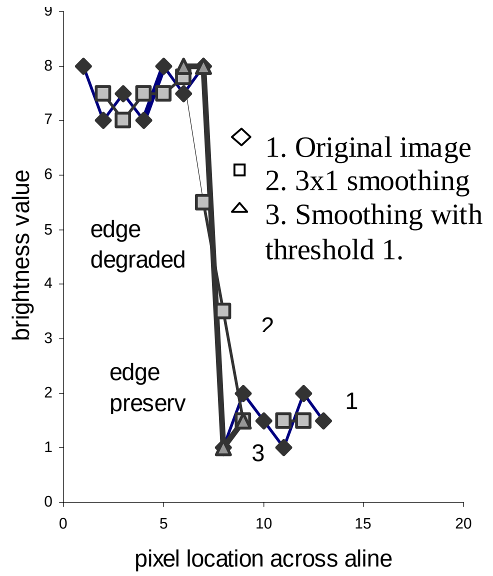


Fig. (1): Illustration of the effect of 3×1 averaging across a single line of image data with and without thresholding

Median Filtering

Disadvantages of the thresholding method for avoiding edge deterioration are that it adds to the computational cost of the smoothing operation and T must be determined. An alternative technique for smoothing in which the edges in an image are maintained is that of median filtering. In this the pixel at the centre of the template is given the median brightness value of all the pixels covered by the template i.e. that value which has as many values higher and lower (For example, the median of 4, 6, 3, 7, 9, 2, 1, 8, 8 is 6). Fig. (2). shows the effect of median filtering on a single line of image data compared with simple box car averaging. which uses the mean of pixel brightness values. Again, it can be seen that most of the original edge is preserved.

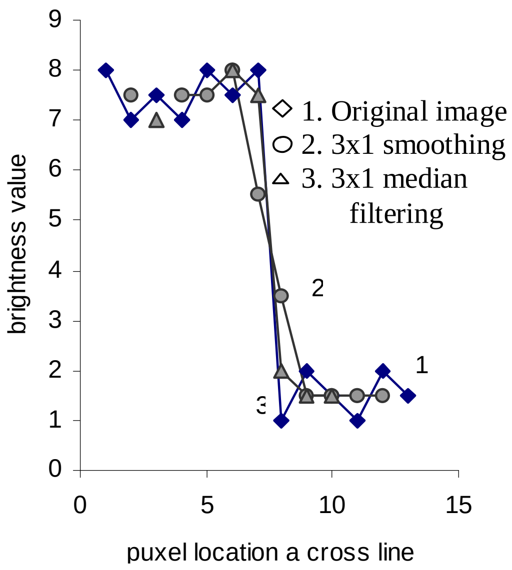


Fig. (2): comparison averaging and median filtering of a single line of image data

An application for which median filtering is well suited is the removal of impulse-like noise. This is because pixels corresponding to noise spikes are atypical in their neighborhood and will be replaced by the most typical pixel in that neighborhood [5].

Gaussian Filter

The Gaussian distribution in 1-D has the form:

$$G(x,y)=\frac{1}{\sqrt{2\pi}\sigma}e^{-\frac{x^2}{2\sigma^2}} \tag{8}$$

Where σ is the standard deviation of the distribution. We have also assumed that the distribution has a mean of zero (*i.e.* it is centered on the line x=0). The distribution is illustrated in Fig. (3).

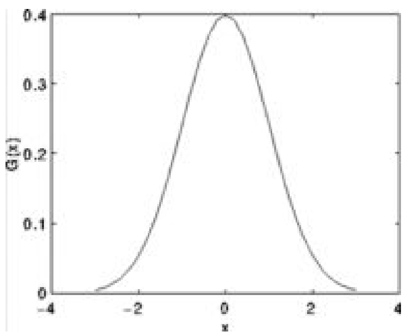


Fig. (3): 1-D Gaussian distribution with mean 0 and σ =1

In 2-D, an isotropic (i.e. circularly symmetric) Gaussian has the form:

$$G(x,y)=\frac{1}{2\pi\sigma^2}e^{-\left(\frac{x^2+y^2}{2\sigma^2}\right)} \tag{9}$$

This distribution is shown in Fig.(4).

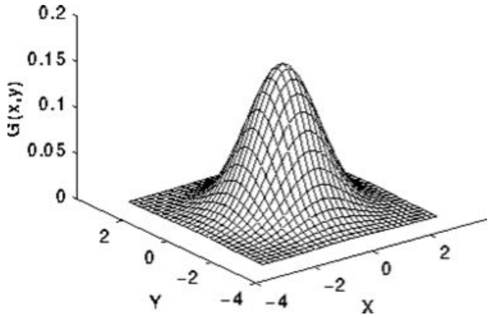


Fig. (4): 2-D Gaussian distribution with mean (0,0) and σ =1

The idea of Gaussian smoothing is to use this 2-D distribution as a `point-spread' function, and this is achieved by convolution. Since the image is stored as a collection of discrete pixels we need to produce a discrete approximation to the Gaussian function before we can perform the convolution. In theory, the Gaussian distribution is non-zero everywhere, which would require an infinitely large convolution kernel, but in practice it is effectively zero more than about three standard deviations from the mean, and so we can truncate the kernel at this point. Fig. (5) shows a suitable integer-valued convolution kernel that approximates a Gaussian with σ =1.0.

$$\frac{1}{273}\begin{array}{|c|c|c|c|c|}\hline 1 & 4 & 7 & 4 & 1 \\ \hline 4 & 16 & 26 & 16 & 4 \\ \hline 7 & 26 & 41 & 26 & 7 \\ \hline 4 & 16 & 26 & 16 & 4 \\ \hline 1 & 4 & 7 & 4 & 1 \\ \hline \end{array}$$

Figure (5): Discrete approximation to Gaussian function with σ =1.0

Once a suitable kernel has been calculated, then the Gaussian smoothing can be performed using standard convolution method. The convolution can in fact be performed fairly quickly since the equation for the 2-D isotropic Gaussian shown above is separable into x and y components. Thus the 2-D convolution can be performed by first convolving with a 1-D Gaussian in the *x* direction, and then convolving with another 1-D Gaussian in the *y* direction. (The Gaussian is in fact the *only* completely circularly symmetric operator which can be decomposed in such a way).

A further way to compute a Gaussian smoothing with a large standard deviation is to convolve an image several times with a smaller Gaussian. While this is computationally complex, it can have applicability if the processing is carried out using a hardware pipeline. The Gaussian filter not only has utility in engineering applications. It is also attracting attention from computational biologists because it has been attributed with some amount of biological plausibility, *e.g.* some cells in the visual pathways of the brain often have an approximately Gaussian response [7,8,9].

Result & Discussion

In this paper we present one of the most common operation in image processing techniques is that smoothing operation and it's equivalent to low pass filtering where the noise image can be enhanced by cut off the high frequency from the degradation image.

Several technique include two field spatial and frequency domain have been used to perform the enhancement process for the noisy image which represented in the Fig.(6) such as mean value filtering (averaging), median filter, Gaussian filter, and adaptive technique consist of duplicated two filters (median and Gaussian) in different properties of filter like as block size of median filter, band width of Gaussian filter.

In the mean value smoothing we got a good result as shown in Fig. (7), it notice that the result become more acceptable if the noise distribution in the image is smaller than the smallest objects of interest in the image, but the blurring of edge is a serious disadvantage, and this problem was solved by assuming a threshold value (T) as explained in section (2).

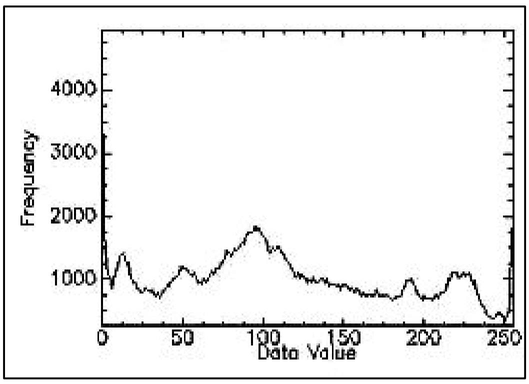
In median filter the blurring of the edge was reduced, where in this technique the current point in the image was replaced by the median of brightness, and it's note that the median of brightness in the neighborhood is not affected by individual noise speckle and so median smoothing eliminates impulsive noise quite well. As median filtering doesn't bluer edges much, it can be applied iteratively.

The main disadvantage of median filter in rectangular neighbourhood is it's damaging at thin lines and sharp corners in the image. So we use an adaptive technique depend on hybrid of two filter to overcome on some of problems of enhancement operation see table (1) which represent the statistical properties of the original image and noisy image and compared this properties with the other of using techniques, where we show that the standard division of adaptive filtered image is the nearest from the standard division of the original image as well as the mean of Gaussian filtered image and the adaptive filtered image is closely from the original image.

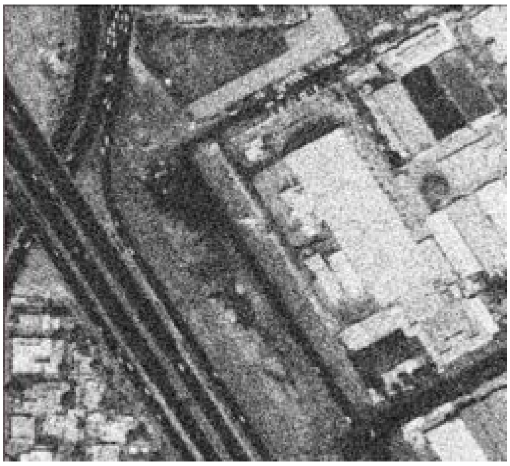
Table (1): represent the statistical properties of original image, noisy image and different filtered images

Technique name	*Min.*	*Max.*	*mean*	*Stdv.*
Original image	0	255	115.1145	70.73317
Noisy image	0	255	125.09059	69.2478
Filtered image by Mean value	41	255	145.4169	59.238
Filtered image by Threshold mean value	33	247	125.9465	54.8382
Filtered image by Gaussian filter	4	255	119.7296	58.2937
Filtered image by Median filter	0	255	107.83216	76.332614
Filtered image by Adaptive filter	0	255	110.7626	72.64124

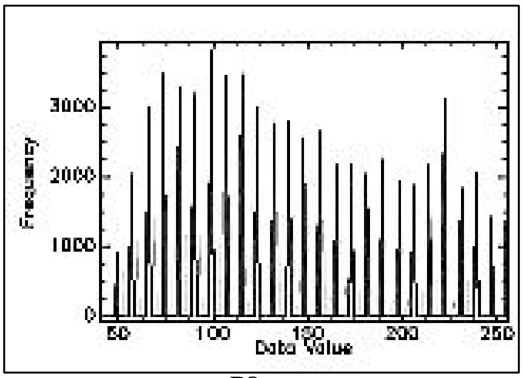
A1



A2

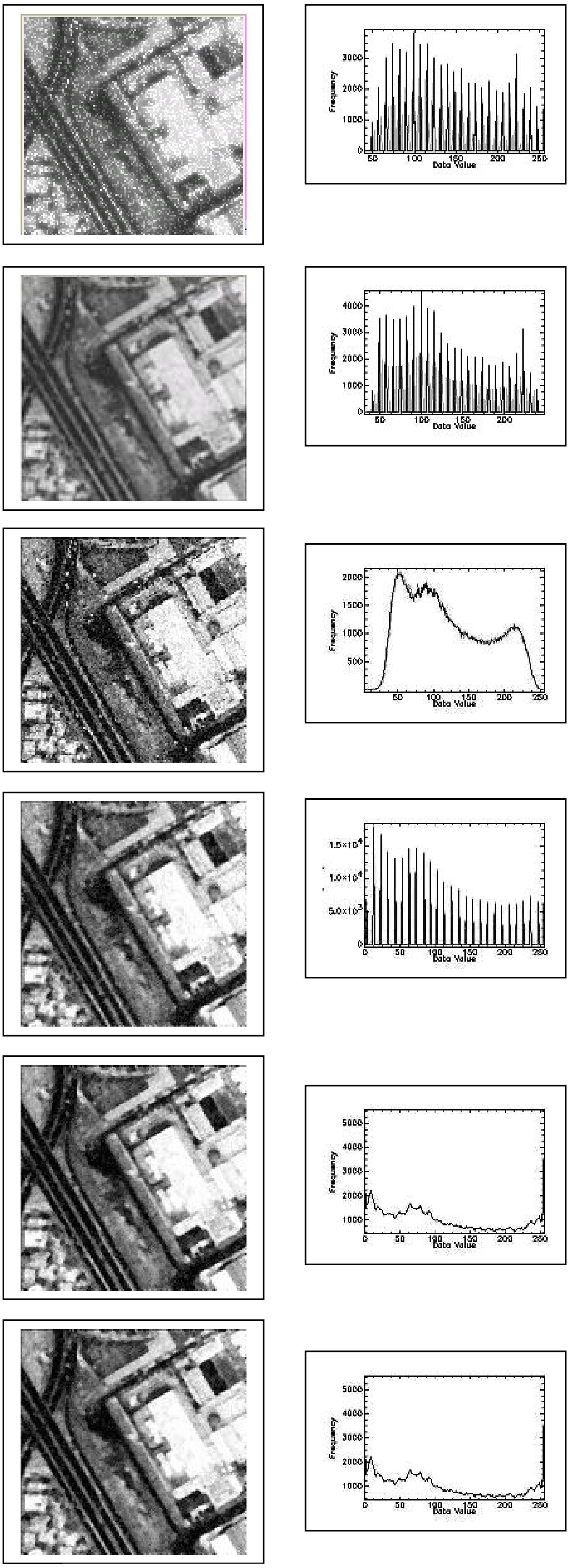


B1



B2

Fig. (6): A1. original image represent part of Baghdad sity with statistical properties:
A2. histogram of original image.
B1. noisy of original image with staitstical properties:
B2. histogram of noisy image.



[1] smoothing image using
mean value with .
Block size=9 x 9

[2] smoothing image using
mean value with .
block size=5 x 5
treshold value=5

[3] smoothing image using
gausian filter with
block size=9 x 9

[4] smoothing image using
median filter with
block size=9 x 9

[5] smoothing image using
adaptive filter with
gausian block size=9 x 9
median block size= 7 x 7

[6] smoothing image using
adaptive filter with
gausian block size=9 x 9
median block size= 9 x 9

Figure(7): final result of using different smoothing techniques to enhance the image

References

[1] E. U. scott., "Computer Vision and Image Processing", a practice Approach using CVIP tools, Prentice Hall PTR, upper Ssaddle River, NJ 07458., (1998).

[2] T. M. Lillesand and R. W. Kiefer., "Remote Sensing, Principles and Image Interpretation", 4h. Ed., John Wiley and Sons, INC.,(2000).

[3] J. R. Jenes., "Introduction Digital Image Processing", Prentice-Hall, New Jersey., (1986).

[4] S. M. Ali, and R.E. Burge., "New Automatic Techniques For Smoothing And Segmentation Sar Image", Signal Processing North, Vol.14., (1988).

[5] J. A. riichards, X. Jia., "Remote Sensing Digital Image Analysis", third edition, Canberra, Australia, August., (1988).

[6] E. M. Eliason and A.S. Meewan., "Adaptive Box Filters For Removal Of Random Noise From Digital Images", photogram metric engineering and Remote Sensing, 56, 453-458., (1990).

[7] E. Davies *Machine Vision.*, "Theory, Algorithms and Practicalities", Academic Press, pp 42 - 44., (1990).

[8] R. Gonzalez and R. Woods., "Digital Image Processing", Addison - Wesley Publishing Company, p 191., (1992).

[9] R. Haralick and L. Shapiro., "Computer and Robot Vision", dison-Wesley Publishing Company Vol. 1, Chap. 7., (1992).