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RESEARCH ARTICLE

AN INVESTICATION OF NOISE REMOVING TECHNIQUS USED IN SPATIAL DOMAIN IMAGE PROCESSING

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Abstract— The term Digital Image Processing denotes the process of digital images with the use of digital computer. Digital image processing is used in various types of application areas. The problem of image enhancement is considered as a problem of quality improvement. Digital images are contains various types of noises which are reduces the quality of images. Noises can be removed by various enhancement techniques. Filtering is the process used to remove the noise in the digital images. Digital images can be either spatial domain or frequency domain. This paper investigates various techniques used in spatial domain image processing.

Key Terms: - spatial domain; filter; smoothing; sharpening; noise

I. INTRODUCTION

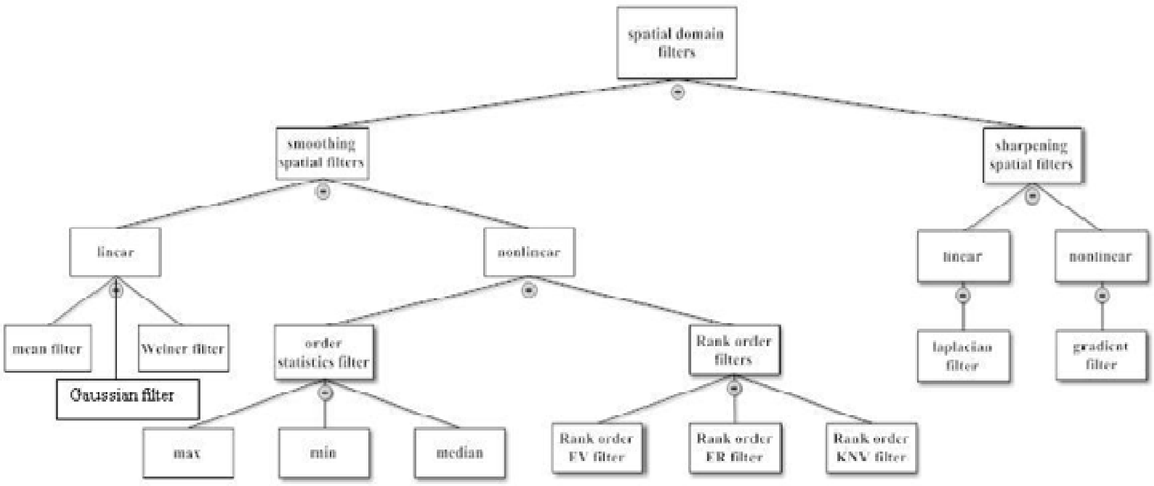
Image enhancement has become a component of many important image processing and computer vision applications. Image enhancement involves taking an image and improving it visually, typically by taking advantage of the response to visual stimuli. Image noise represents unwanted or undesired information that can occur during the image capture, transmission, processing or acquisition, and may be dependent or independent of the image content. [1].

Spatial filtering term is the filtering operations that are performed directly on the pixels of an image. The process consists simply of moving the filter mask from point to point in an image. At each point (x,y) the response of the filter at that point is calculated using a predefined relationship.

Spatial filter can be classified into i) smoothing spatial filters and ii) sharpening spatial filters. These filters can be either linear or nonlinear. In linear filter each pixel value in the output image is a weighted sum of the pixel in the neighborhood of the corresponding pixel in the input image. Nonlinear filtering operation is based conditionally on the values of the pixels in the neighborhood, and they do not explicitly use coefficients in the sum-of-products manner. Noise reduction can be achieved effectively with a nonlinear filter.

II. SMOOTHING SPATIAL FILTERS

Smoothing filters are used for noise reduction and blurring operations. Blurring can be used as a preprocessing step for other image processing operations. A smoothing filter is used to remove noise from an image. Each pixel is represented by three scalar values representing the red, green, and blue chromatic intensities. At a pixel studied, a smoothing filter takes into account the pixels surrounding it in order to make a determination of a more accurate version of this pixel. By taking neighboring pixels into consideration, extreme "noisy" pixels can be filtered out. Unfortunately, extreme pixels can also represent original fine details, which can also be lost due to the smoothing process [2]. Smoothing spatial filters can be either linear or nonlinear filters.



A. SMOOTHING LINEAR FILTERS

The response of a smoothing linear spatial filter is simply the average of the pixels contained in the neighborhood of the filter mask. These kinds of filters are called averaging filters or low pass filters. Mean filter and wiener filter are the two types of smoothing spatial linear filters.

1) MEAN FILTER:

The filter computes the value of each output pixel by finding the statistical mean of the neighborhood of the corresponding input pixel. The following figure illustrates the local effect of the Mean Filter. The statistical mean of the neighborhood on the left is passed as the output value associated with the pixel at the center of the neighborhood.

28	26	50
27	25	29
25	30	32

→ 30.22 → 30

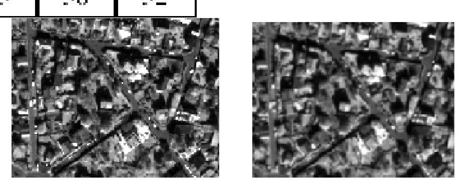


Fig 1 The effect of mean filter

2) WIENER FILTER:

The Wiener filter is a classic method for attempting to remove noise from images. It was developed (for 1D applications) by Norbert Wiener in the 1930's and 1940's. The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously. The Wiener filtering is optimal in terms of the mean square error [3]. The Wiener filter has two separate parts, an inverse filtering part and a noise smoothing part. It not only performs the deconvolution by inverse filtering (high pass filtering) but also removes the noise with a compression operation (low pass filtering) [4].

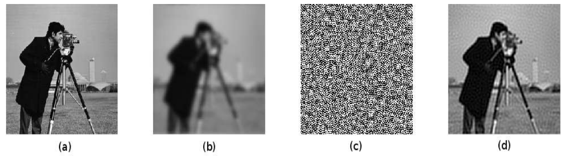


Fig 2 Wiener filter applied to a noise image. (a) Original image. (b) Image blurred (c) Image after inverse filter. (d) Image after the Wiener filter.

Image statistics vary too much from a region to another even within the same image. Thus, both global statistics (mean variance, etc. of the whole image) and local statistics (mean, variance, etc. of a small region or sub-image) are important. Wiener filtering is based on both the global statistics and local statistics.

3) GAUSSIAN FILTER:

A Gaussian filters smoothens an image by calculating weighted averages in a filter box. The Gaussian Smoothing Operator performs a weighted average of surrounding pixels based on the Gaussian distribution. It is used to remove Gaussian noise and is a realistic model of defocused lens.

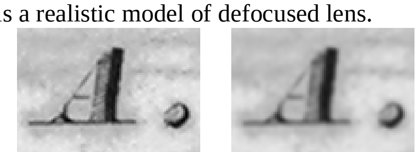


Fig 3 Gaussian smoothing

This removes fine image detail and noise leaving only larger scale changes. Gaussian Blurs produce a very pure smoothing effect without side effects. A Gaussian Blur is distinct from other blurs in that it has a well-defined effect on different levels of detail within an image.

B. SMOOTHING NONLINEAR FILTERS

Nonlinear filters have quite different behavior compared to linear filters. A nonlinear filter can produce results that vary in a non-intuitive manner. Nonlinear filters are can be fall under the category of order statistic filter or rank order filters.

I. ORDER STATISTIC FILTER:

Order-statistics filters are nonlinear spatial filters whose response is based on ordering (ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of the center pixel with the value determined by the ranking result

1) Min and Max Filter:

The minimum filter selects the smallest value within the pixel values and maximum filter selects the largest value within of pixel values. This is accomplished by a procedure [5] which first finds the minimum and maximum intensity values of all the pixels within a windowed region around the pixel. If the intensity of the central pixel lies within the intensity range spread of its neighbors, it is passed on to the output image unchanged.

TABLE 1

The example and description of max, min and midpoint filters

EXAMPLE IMAGE	FILTER TYPE	DESCRIPTION
22 77 48 150 77 158 0 77 219	Max Filter	The center pixel would be changed from 77 to 219 as it is the brightest pixel within the current window.
	Min Filter	The center pixel would be changed from 77 to 0 as it is the darkest pixel within the current window.
	Midpoint Filter	The center pixel would be changed from 77 to 109 as it is the midpoint between the brightest pixel 219 and the darkest pixel 0 within the current window.

However, if the central pixel intensity is greater than the maximum value, it is set equal to the maximum value; if the central pixel intensity is less than the minimum value, it is set equal to the minimum value[6].

2) Median Filter:

Median filter is the nonlinear filter more used to remove the impulsive noise from an image. With the median filter, all the pixels in the neighborhood are ranked by intensity level and the center pixel is replaced by that pixel which is mid-way in ranking [7].

Fig 4 a) Noise image b) Most of the noise is removed by using median filter

3) Midpoint Filter:

The Midpoint filter blurs the image by replacing each pixel with the average of the highest pixel and the lowest pixel (with respect to intensity) within the specified window size.

Midpoint = (darkest+lightest)/2

II. RANK ORDER FILTERS:

Rank-order filters are spatial-domain nonlinear filters, which are based on the correction of the local histogram within the filtering window. Rank-order filters are adaptive to the signal local statistics. Image processing with rank-order filters is reduced to the creation of the filtering interval from the limited number of pixels belonging to the filtering window with the further correction of the central pixel within the window using some kind of averaging of the selected pixels. There are three rank-order filters: *Rank-order EV filter*, *Rank-order KNV filter* and *Rank-order ER filter* (classification of L. Yaroslavsky)[10].

1) Rank-order EV filter:

A filtering interval for this filter is composed of all brightness values belonging to the pixels within the filtering window whose absolute difference from the central pixel brightness value is less than or equal to EV (which is a main control parameter for this filter). The most important property of this filter is that it smoothens the brightness jumps which are less than or equal to EV, and preserves the brightness jumps that are greater than EV. The EV filter is highly effective for reduction of white noise[10].

2) Rank-order ER filter:

A filtering interval for this filter is composed of all brightness values belonging to the pixels within the filtering window whose rank difference from the central pixel brightness value rank in the variational series is less than or equal to ER, which is a main control parameter for this filter. This filter is effective for the reduction of complicated noise types with unknown statistics, and for the reduction of any complicated noise containing an impulsive component10].

3) Rank-order KNV filter:

A filtering interval for this filter is composed of the number of brightness values (belonging to the pixels within the filtering window) which is equal to KNV and whose values are closest to the central pixel brightness value (KNV is a main control parameter for this filter). The most important property of this filter is that it smoothens only the objects whose area is less than the number of square pixels that are equal to KNV, and preserve the objects whose area is greater than KNV [10].

III. SHARPENING SPATIAL FILTERS

The main aim in image sharpening is to highlight fine detail in the image, or to enhance detail that has been blurred (perhaps due to noise or other effects, such as motion). Sharpening is used to enhance the image details by adding the edges to the input images. Sharpening filter uses the derivative operators to remove the noise. The strength of the response of a derivative operator is proportional to the degree of discontinuity of the image at the point at which the operator is applied.

1) SHARPENING LINEAR FILTER

In linear filtering the output values are linear combinations of the pixels in the original image. Linear methods are far more amenable to mathematical analysis than are nonlinear ones, and are consequently far better understood. For example, if a linear filter is applied to the output from another linear filter, then the result is a third linear filter. This filter is a high pass spatial filter.

LAPLACIAN FILTER:

The Laplacian operator generally highlights point, lines, and edges in the image and suppresses uniform and smoothly varying regions. The Laplacian is based upon the second derivative:

$$\nabla^2 f = \partial^2 f/\partial x^2 + \partial^2 f/\partial y^2$$

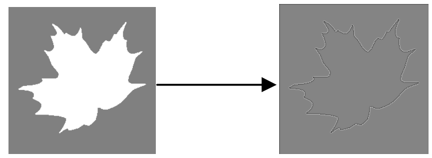


Fig 5 Initial image and Laplacian image

A Laplacian filter forms another basis for edge detection methods. A Laplacian filter can be used to compute the second derivatives of an image, which measure the rate at which the first derivatives change. This helps to determine if a change in adjacent pixel values is an edge or a continuous progression. The second derivative (Laplacian) is more sensitive to changes. The Laplacian exhibits a "double edge" effect.

1) SHARPENING NONLINEAR FILTER

Sharpening used to enhance line structures or other details in an image. Gradient used to enhance prominent edges. First-order derivatives of a digital image are based on various approximations of the 2-D gradient. The gradient is defined as the two-dimensional column vector. Nonlinear sharpening filters are uses various operators like Sobel, prewitt and Robert.

GRADIENT FILTER:

One way to detect edges or variations within a region of an image is by using the gradient operator. The gradient is a **vector** which has magnitude and direction (e.g. Fig 6). Magnitude provides information about edge strength. Direction is perpendicular to the direction of the edge. Whereas the Laplacian is based upon the second derivative on an image, the gradient is based upon the first derivative. The gradient of an image f(x, y) is defined as:

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \partial f(x,y)/\partial x \\ \partial f(x,y)/\partial y \end{bmatrix}$$

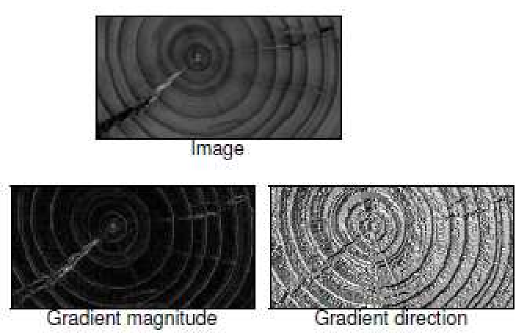


Fig 6 Gradient magnitude and direction

Sobel operator used to computes the magnitude of the gradient and prewitt operator computes the directional gradient filter. This also gives the direction of the edge (in 45◦ steps). Robert's operator is easy to compute and works in highly sensitive noise.

IV. CONCLUSION

Spatial domain represents an important enhancement technique that can effectively be used to remove various types of noise in digital images. These spatial filters typically operate on small neighborhood 3 x 3 to 11 x 11 and some of them can be implemented as convolution masks [8]. In many image processing applications, spatial domain filters have been employed very effectively in removing different types of noise [9]. Table 2 shows some information about spatial domain filter and the noises which can be removed by those filter. However choosing noise reduction technique is difficult task in image processing. The goals vary from noise removal to feature abstraction. Linear and nonlinear filters are the two most utilized forms of filter construction. Knowing which type of filter to select depends on the goals and nature of the image data. In cases where the input data contains a large amount of noise but the magnitude is low, a linear low-pass filter may suffice. Conversely, if an image contains a low amount of noise but with relatively high magnitude, then a median filter may be more appropriate. In either case, the filter process changes the overall frequency content of the image.

TABLE 2
Filters name and properties

Filter name	Filter type	Noise type & performance
Mean filter	Linear smoothing	Gaussian noise
Weiner filter	Linear smoothing	Additive noise
Gaussian filter	Linear smoothing	Gaussian noise
Max filter	Nonlinear smoothing	Salt noise(brightest point)
Min filter	Nonlinear smoothing	Pepper noise(darkest point)
Midpoint filter	Nonlinear smoothing	Gaussian and uniform noise
Median filter	Nonlinear smoothing	impulsive noise
Rank order EV filter	Nonlinear smoothing	reduction of white noise
Rank order ER filter	Nonlinear smoothing	Complicated noise with impulsive component
Rank order KNV filter	Nonlinear smoothing	Reduction of white noise and speckle noise
Laplacian filter	Linear sharpening	Edge detection
Gradient filter	Nonlinear sharpening	Noise reduction

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