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NEW DESGIN OF NOISE PREDICTION IN DIGITAL COLOR IMAGES

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Abstract: - This paper deals with nonlinear two-dimensional filters for image restoration. The filter employs classic predictor structure with nonlinear predictor and prediction error processed by a static (memoryless) nonlinear element or by a nonlinear two-dimensional filter. The filters discussed are both recursive and non-recursive. Even in the case of recursive structures stability is guaranteed. The filters are suitable for impulsive noise removal from color images. Preservation of textures and fine details are advantages of the filters proposed. The experimental data prove that these filters outperform classic nonlinear median-based filters.

Keywords: Digital Filters, Image Processing, Gamma Compensation

1. INTRODUCTION

Nonlinear filters show a good solution of solving the problem of the nonlinear data processing by using nonlinear structures [l]. Most of them were non-recursive. Recursive filters are more efficient from the point of view of numbers of arithmetic operations needed in their implementations [2, 3]. Stability was the major point of designing such structures of these filters. Passive digital systems showed to be a powerful concept to solve the stability problems [4, 5]. Predictive coding of signals and Image Compression are showing that this concept is very useful [6- 8].

This paper is considering the nonlinear two-dimensional digital filters in the filter design. Nonlinear spatial predictor is used for noise detection. Noise detection and prediction method depends on the Gamma distribution of local samples is proposed. The filter is designed mostly for color image processing. The goal of the paper is to examine how an additional prediction path improves the performance of nonlinear filters.

New original structure which includes a filter that precedes the predicted signal is presented. The new structure depends on examining the Gamma distribution of the local area around the processed pixel. Then check whether that the processed pixel is within the distribution or not. This structure has been introduced with the aim to reduce degradation of thin lines and fine details caused by classic nonlinear filters.

2. GAMMA DISTRIBUTION

The gamma distribution used deeply in the work related to other distributions and precipitation quantities. The gamma distribution is used to measure the probability of events for the random event processing in many applications such as inventory control, economic theory, and insurance risk theory [9]. The main conditions underlying the gamma distribution are:

1. Flexible implementation of measurement for the possible occurrence numbers to wide range of data.
2. Repetition time is independent in one unit of measurement and not affected in other related units.
3. The same average value of occurrences should be remains from unit to unit.

Definition 1: Gamma function is defined as:

$$\Gamma(\alpha) = \int_0^{\infty} x^{\alpha-1} e^{-x} dx \quad ; \alpha > 0$$

Definition 2: Probability of Gamma distribution for continuous random variable x is:

$$f(x) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}} x^{\alpha-1} e^{-\frac{x}{\beta}} \qquad \alpha, \beta > 0, \qquad x \sim GAM(\alpha, \beta)$$

For Gamma distribution, the mean value is calculated as $\{\mu = \alpha\beta\}$ and the variance is $\{\sigma^2 = \alpha\beta^2\}$.

Now, we can find the parameters α , β from the above μ and σ^2 as follow:

$$\alpha = \frac{\mu^2}{\sigma^2} \quad ; \quad \beta = \frac{\sigma^2}{\mu}$$

Where, $\mu = \frac{\sum_1^n x_i}{n} \quad ; \quad \sigma^2 = \frac{\sum_1^n (x_i - \mu)^2}{n}$

The parameters of the shape (α) and the scale (β) are the distributional parameters of gamma function (Figure 1).

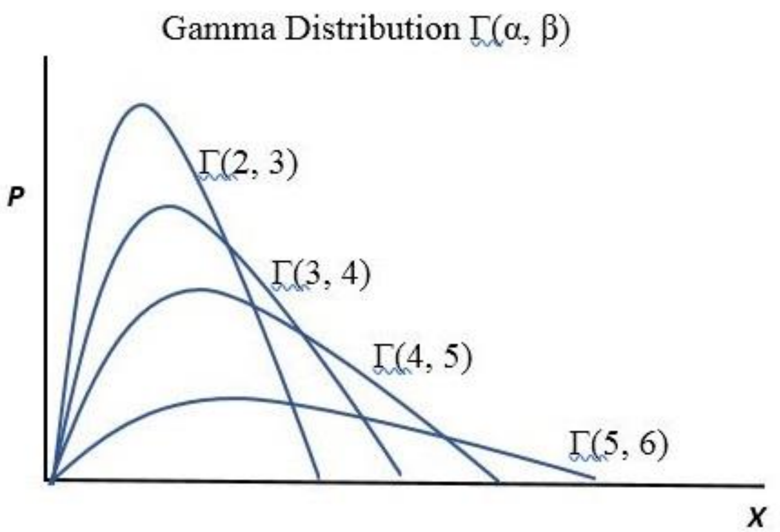

Figure 1: Probability (*p*) of the Gamma distribution (*Γ*) according the variation of (α, β) for the samples (x).

3. FILTER PROCESSING

The median filter MF is processed in RGB color space according to its linear transformation. Linear transformation is simplified the filters structure and clarify the memory allocation and the three image components are processed independently [10]. In some modifications of this simple filter it is easy to expand this application to a vector filter.

Computer and camera images are Gamma corrected. Gamma distribution and correction idea is implemented in the filter design. Noisy pixels are considered to be out of the Gamma distribution of the local samples around the processed pixel. Switching method is proposed for the filter structure. The reference filter is applied only for the predicted pixels that considered as corrupted with noise. Figure 2 illustrate the filter structure.

A 3x3 sampling window is passing through the whole image. The processed pixel is the center of sampling window. The nine samples of the window are considered as Gamma distributed according to the preprocessing of the image in computer screen or camera. When the processed pixel is corrupted by noise, it causes a certain shifting in the Gamma distribution as shown in Figure 3.

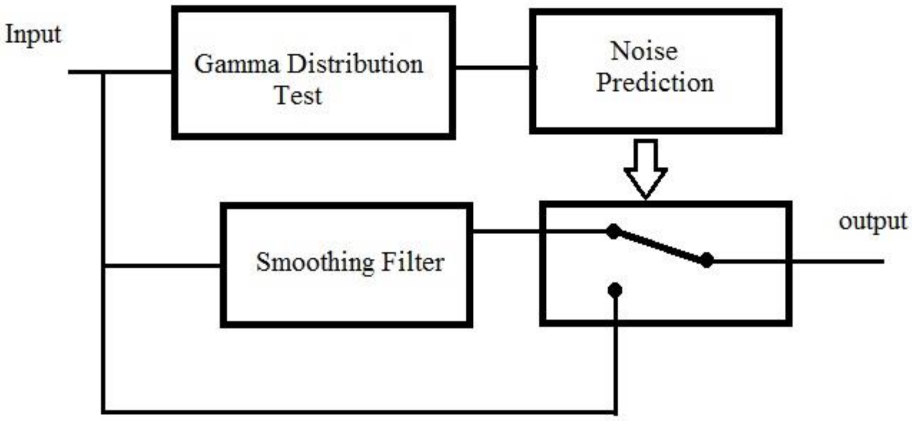

Figure 2: Filter Structure.

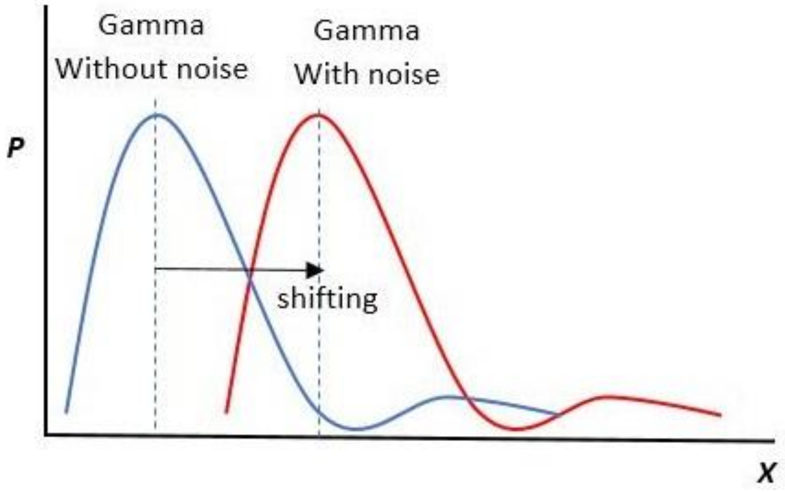

Figure 3: Gamma distribution comparison in presence of noise and without noise.

When the peak value of the probability function is closing to the processed pixel, it is considered that this pixel is not corrupted with noise. Usually, the Gamma distribution shifting amount depends on how far the corrupted pixel value from the normal Gamma distribution.

The described filters process textures and small details much better than median filters of different kind. Nevertheless, filters described above degrade thin lines exhibiting high contrast to background. It consists in processing of the prediction error by a nonlinear filter rather than by memory-less nonlinear element.

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4. EXPERIMENTAL RESULTS

The test images selected are Lena, Boats, Baboon, and Pepper. The images are corrupted with impulsive noise. The images are processed by filters with and without the prediction structure. Random disturbance to the RGB components is applied independently with impulsive noise of amplitude (0-255). The distribution of impulse values as well as of pixel choice is uniform. The probability that a given pixel in a given component will be corrupted is p.

Filters efficiency is proved by objective quality calculation of PSNR. Filter performance with prediction (PF) is superior to that of the median filters in subjective quality also. Fine texture is better preserved in the filter output with a feedback loop. Table (1) shows the noticed increasing of the PSNR [dB] when the prediction is used. The improvement is highest when recursive filter (RPF) is applied compared with recursive median filter (RMF) as shown in Table 2.

Figure 4 illustrates preservation of thin lines implied by application of the proposed structure. This advantageous property is obtained with small decrease of efficiency of rejection of impulsive noise (Table 1 and 2).

Table 1: The results of noise rejection for non-recursive proposed filter.

Input Image	PSNR for 5% noise applied			PSNR for 10% noise applied		
	Noisy Image	MF output	PF output	Noisy Image	MF output	PF output
Baboon	13.55	15.56	21.89	10.56	15.38	18.84
Boats	13.41	21.55	26.59	10.40	20.91	23.51
Lena	13.39	23.43	28.52	10.44	22.78	25.31
Peppers	13.21	25.15	29.28	10.23	24.30	25.82

Table 2: The results of noise rejection for recursive proposed filter.

Input Image	PSNR for 5% noise applied			PSNR for 10% noise applied		
	Noisy Image	RMF output	RPF output	Noisy Image	RMF output	RPF output
Baboon	13.62	15.72	21.92	10.61	15.52	29.11
Boats	13.44	21.70	26.94	10.43	21.21	23.74
Lena	13.44	23.62	28.83	10.46	23.10	25.41
Peppers	13.25	25.47	29.22	10.29	24.85	26.69


Original Image | Corrupted Image by 5% impulse noise


Median filter output | Proposed filter output

Figure 4: Rejection of impulse noise with probability of p=5% using proposed recursive filter (RPF) compared with median filter (RMF).

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