Modified Progressive Switched Median Filter for Image Enhancement

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Abstract

Modified progressive switching median filter is proposed. It is constructed using introduction of the impulse noise detector from adaptive switching median filter into the progressive switching median filter. The results of comparative analysis of new algorithm with other filters are presented. The results show that the proposed algorithm is more efficient in the case of random-valued impulse noise removing from digital images.

Keywords: *impulse noise, impulse detection, nonlinear filter, order statistics, face detection, image preprocessing*

1. INTRODUCTION

Images corrupted by impulse noise often occur in practical applications. Impulse noise may appear in digital images because of channel decoder damages, dyeing down of signal in communication links, communication subscriber's moving, video sensor's noises and other [1].

In a variety of impulse noise models for images, corrupted pixels are often replaced with values equal to or near the maximum or minimum of the allowable dynamic range. For 8-bit images, this typically corresponds to fixed values near 0 or 255. We consider here a more general noise model in which a noisy pixel can take on arbitrary values in the dynamic range according to some underlying probability distribution. Let $v(n)$ and $x(n)$ denote the luminance values of the original image and the noisy image, respectively, at pixel location $n=[n_1,n_2]$. Then, for an impulse noise model with error probability p, we have

$$x(n)=\begin{cases} v(n), & with \quad probability \quad 1-p, \\ \eta(n), & with \quad probability \quad p, \end{cases} \qquad (1)$$

where $\eta(n)$ is an identically distributed, independent random process with an arbitrary underlying probability density function. If noise model describes fixed-valued impulse noise (salt-and-pepper noise) then $\eta(n)$ can only take on values 0 or 255 with equal probabilities. For random-valued impulse noise $\eta(n)$ is described by a uniform distribution from 0 to 255.

There are many researches who are trying to solve the problem of salt-and-pepper impulse noise removal, and they had achieved very good results [1, 2, 6, 8]. The removal of random-valued noise is more difficult problem, because the differences in gray levels between a noisy pixel and its noise-free neighbour most of the times are less significant [3]. Some impulse noise removal algorithms have demonstrated sufficient effectiveness in restoration of random-valued impulse noise corrupted images. Modern examples of them are: directed weighted median filter (DWM) [4], adaptive central weighted median filter (ACWM) [5] and signal-depended rank ordered mean filter (SDROM) [6].

In this work noise impulses detection and removing problems are considered separately and improved algorithm for random-valued noise removal is proposed.

The following metrics of algorithms effectiveness are used to provide the comparative analysis of these algorithms:

- peak signal-to-noise ratio (PSNR) [1];
- information fidelity criteria (IFC) [7];
- visually perceived quality of restored images.

2. MODIFIED PROGRESSIVE SWITCHING MEDIAN FILTER

The proposed algorithm (MPSM) is based on the known progressive switching median filter (PSM) [8] and adaptive central weighted median filter [2]. It uses switching schema which includes two stages of noisy image processing:

1. Preliminarily detection of noise corrupted pixels of digital image.

2. Filtering of noise impulses which have been detected in first stage of processing using gathered information about image properties.

At first stage ACWM-based impulse detector is used for detect noise corrupted pixels and at the second stage PSM filtering procedure is used to replace such pixels with approximately correct values. At the next section some results of image enhancement are depicted.

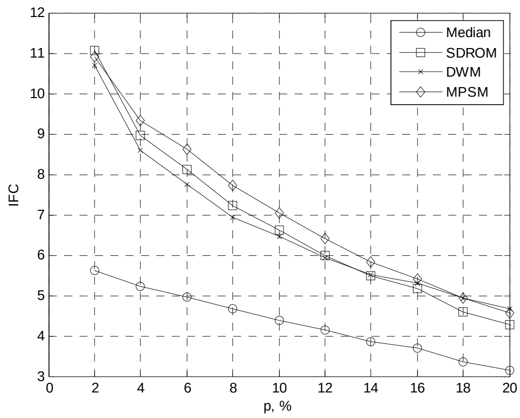

Figure 1. The dependence of IFC of restored image "Lena" from the random-valued impulse noise density

3. IMAGE ENHANCEMENT RESULTS

Above in Figure 1 IFC values of restored test image "Lena" for the set of filters are depicted. Results show that the proposed MPSM algorithm provides better IFC values than other considered filters if impulse noise density is relatively low (p ~ 10-20%). Its IFC value is about 5% more then ones for other considered filters.

Also it's noticeable from analysis of restored images that the visual quality which is provided by MPSM filter is higher that one for other considered algorithms.

4. USING MPSM FILTER IN FACE DETECTION PREPROCESSING

Images containing faces are essential to intelligent vision-based human computer interaction, and research efforts in face processing include face recognition, face tracking, pose estimation, and expression recognition. Often it's needed to detect the faces on noisy images. Below in Table 1 the face detection errors count in dependence of preprocessing algorithm is depicted. The Viola-Jones face detection algorithm [9] was used. Two types of errors are calculated: the missed faces (I) and the false-hits (II).

It can be noticed that using the MPSM filter on preprocessing stage provides better results in the set of situations especially if we would take into consideration only missed faces errors.

Table 1

Preprocessing influence on the face detection results
(10% random-valued impulse noise)

Image index	Count of faces	Detection errors							
		Original image		Corrupted image		Median filter (5×5)		MPSM	
		I	II	I	II	I	II	I	II
1	5	0	0	0	0	0	1	0	0
2	17	8	1	12	1	12	1	7	1
3	17	7	1	13	1	11	1	8	2
4	10	3	0	5	2	3	0	3	0
5	5	1	0	1	1	1	2	1	0
6	8	2	0	2	0	2	0	2	0
7	9	1	1	1	1	1	1	1	2
8	4	2	1	1	0	2	1	1	0
9	4	3	0	4	0	5	0	5	0
10	4	1	0	2	0	1	0	2	0
Total	83	28	4	41	6	38	7	30	5

5. CONCLUSIONS

Improved progressive switching median filter for random-valued impulse noise removal is proposed. The best random-valued noise detection algorithm and effective filtration algorithm were combined together and it produced new effective filter for random-valued impulse noise removal.

As it was shown by comparative analysis this MPSM filter provides better quality of restored images in comparison with compared to other considered algorithms. The numeric image quality indexes, visually perceived image quality and face detection results after MPSM processing were used in this analysis. MatLab implementations of MPSM filter are available on-line at www.piclab.ru/research/mpsm.html.

6. REFERENCES

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