EFFICIENCY OF THE NEW COLOR IMAGE IMPULSIVE NOISE REDUCTION ALGORITHM

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1. Introduction

Noise suppression of digital images is one of the major problems of the low level image processing. This task is an important part of any signal processing system, especially when the filter output is used for human interpretation. During the last years, many different filters have been proposed [1-3]. However the research is going on and new filtering techniques are being introduced. One of them is the new method of filtration [4], which is designed to eliminate impulsive noise, while maintaining the image texture and preserving image edges. The aim of this paper is to compare the efficiency of the proposed filter with the standard techniques used in the colour image enhancement.

2. Construction of the new filtering technique

The output of the average $\bar{J}(i,j)$ and median $\hat{J}(i,j)$ of pixels surrounding the gray scale image pixel (i,j) can be treated as values which minimize the appropriate cost functions

$$\bar{J}(i,j)=\arg\min_{\Theta}\left\{\sum_{u=-n_1}^{n_1}\sum_{v=-n_2}^{n_2}\left[I(i+u,j+v)-\Theta\right]^2\right\};\quad \hat{J}(i,j)=\arg\min_{\Theta}\left\{\sum_{u=-n_1}^{n_1}\sum_{v=-n_2}^{n_2}\left|I(i+u,j+v)-\Theta\right|\right\}$$

The new method of noise reduction applied is based on a concept of randomly walking particle [5, 6], which performs a random walk on the image lattice. The transition probability between pixels (i,j) and (k,l) is defined as $P\{(i,j);(k,l)\}=\dfrac{\exp\{-\beta\left|I(i,j)-I(k,l)\right|\}}{Z(i,j)}$, where β is the filter parameter, $\sqcup$ denotes the neighbourhood relation and $Z(i,j)$ is the normalizing constant. The new filter used for colour images, assigns at each pixel (i,j) the value $J^*(i,j)$ which minimizes the probability that the virtual jumping particle will remain at its temporary position. The minimization of the probability $P\{(i,j);(i,j)\}$ is equivalent to the maximization of the statistical sum $Z(i,j)$ and therefore for colour images $J^*(i,j)=\Theta$, for which

$$\mathbf{\Theta}=\arg\max\left\{\sum_{u=-n_1}^{n_1}\sum_{v=-n_2}^{n_2}\exp\{-\beta\left\|\mathbf{J}(i+u,j+v)-\mathbf{\Theta}\right\|\}\right\},$$

and $\|\mathbf{\Phi}\|$ denotes the norm L_1 of vector $\mathbf{\Phi}$.

We have compared the efficiency of the new filter with some of the commonly used procedures of noise reduction used for colour images. Table 1 show the results of the efficiency of the new filtered when compared with the median performed independently on the RGB channels and vector medians with metrics L_1 and L_2 [7]. Table 2 shows our previous results obtained using the same test images, but different programming environment.

METHOD	NMSE [10^{-4}]	RMSE	PSNR [dB]	NCD [10^{-3}]
NONE	514,95	32,165	17,983	43,211
MEDIAN-RGB	17,428	5,917	32,68	19,674
VMF L1	19,064	6,189	32,298	19,758
VMF L2	19,408	6,244	32,222	20,003
PROPOSED FILTER	**6,224**	**3,536**	**37,160**	**3,725**

Tab. 1. New filter compared with the median based techniques. (NMSE – normalized mean square error, RMSE – root of the mean squared error, PSNR – peak signal to noise ratio, NCD – normalized colour difference in Luv space).

METHOD	NMSE [10^{-4}]	FILTER
NONE	516,94	
AMF	81,86	**Arithmetic Mean Filter**
VMF	19,00	**Vector Median Filter**
BDVF	34,48	**Basic Vector Directional Filter**
GVDF	30,00	**Generalized Vector Directional Filter**
DDF	32,55	**Directional Distance Filter**
HF	21,82	**Hybrid Directional Filter**
FVDF	24,81	**Fuzzy Vector Directional Filter**
ANNF	26,10	**Adaptive Nearest Neighbour Filter**
AMNFE	17,10	**Adaptive Nonparametric with exponential Kernel**
BFMA	30,67	**Bayesian Adaptive Filter, with Median and Mean sub-filters**

Tab.2 Filtering results obtained using the standard colour image processing filter [8-10].

As can be seen, the new filter outperforms significantly the standard procedures and therefore it can be used as a fast and efficient method of colour image enhancement. The good efficiency of the new filter is also clearly seen in Fig. 1. In conclusion, the new filter eliminates the impulsive noise, while preserving the image details and it can be used for various multimedia presentations.

3. References

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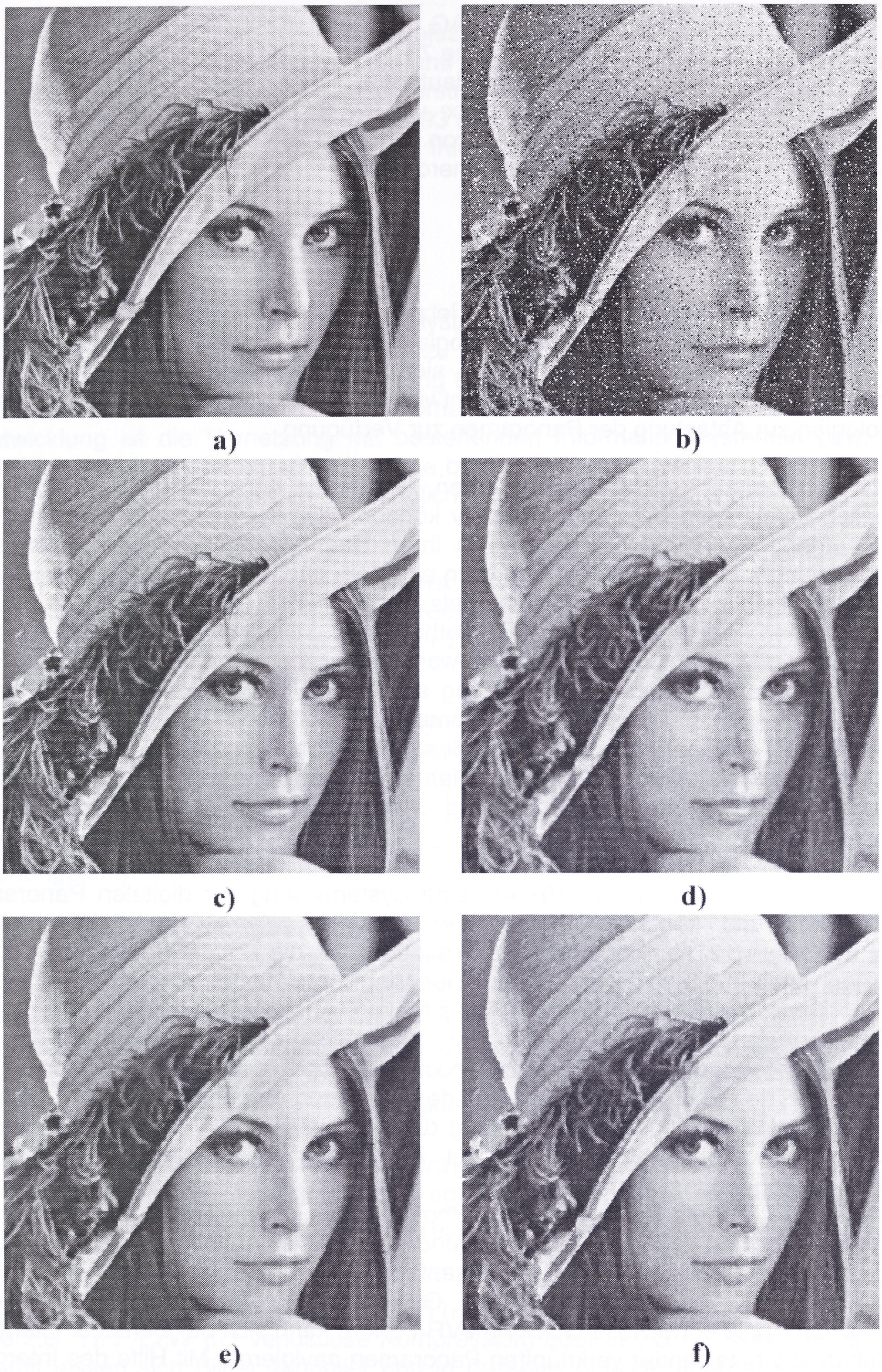

Fig.1. Noise reduction effect of the proposed filter as compared with the standard methods : a) colour test image, b) image distorted by 4% impulsive noise, c) image filtered with the use of the new method, d) adaptive nearest neighbour filter, e) vector median filter, f) basic vector directional filter.