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A Novel Fuzzy Filter for Random Impulse Noise Removal in a Color Video

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Abstract: ***Now a day's digital image processing applications are widely used in various fields such as medical, military, satellite, remote sensing and even web applications also. In any application denoising of image/video is a challenging task because noise removal will increase the digital quality of an image or video and will improve the perceptual visual quality. In spite of the great success of many denoising algorithms, they tend to smooth the fine scale image textures when removing noise, degrading the image visual quality. To address this problem, a new fuzzy filter for the removal of random impulse noise in color video is presented. By working with different successive filtering steps, a very good tradeoff between detail preservation and noise removal is obtained. The experiments show that the proposed method outperforms other state-of-the-art filters both visually and in terms of objective quality measures such as the mean absolute error (MAE) and the peak-signal-to-noise ratio (PSNR).***

Keywords: ***image, medical, military, satellite, fuzzy filter, (MAE), (PSNR), color video.***

I. INTRODUCTION

Images and videos captured from both digital cameras and conventional film cameras will affected with the noise from a variety of sources. These noise elements will create some serious issues for further processing of images in practical applications such as computer vision, artistic work or marketing and also in many fields. There are many types of noises like salt and pepper, Gaussian, speckle and passion. In salt and pepper noise (sparse light and dark disturbances), pixels in the captured image are very different in intensity from their neibouring pixels; the defining characteristic is that the intensity value of a noisy picture element bears no relation to the color of neibouring pixels.

$$\hat{d_i} = \frac{\sum_j w_{ij} n_j}{\sum_j w_{ij}} \qquad (1)$$

II. CONVENTIONAL FILTERS

In this section we discussed various spatial filters and their performance when a noisy input will be given to them. Here in this section we had explained about each filter in detail. Firstly, Savitzky- Golay (SG) filters:

$$\hat{d_i} = \frac{\sum_j w_{ij} n_j}{\sum_j w_{ij}} \qquad (1)$$

Where w_ij is some weight assigned to pixeli and j.

The sum in (1) is ideally performed to whole image to denoise the noisy image. NLM at large noise levels will not give accurate results because the computation of weights of pixels will be different for some neibourhood pixels which looks like same.

$$w_{l,j} = exp\left(\sum_{k\in P} G_\beta\left(\left(n_{l+k} - n_{j+k}\right)^2/2h\right)\right) \qquad (2)$$

In this each weight is computed by similarity quantification between two local patches around noisy pixels n_land n_j as shown in eq. (2). Here, G_βis a Gaussian weakly smooth kernel [1] and P denotes the local patch, typically a square centered at the pixel and h is a temperature parameter controlling the behavior of the weight function. Another popular approach to image denoising is the variation method, where energy functional is minimized to search the desired estimation of x from its noisy observation y.

III. PROPOSED FRAME WORK

The filtering framework presented in this paper is in-tended for color video corrupted by random impulse noise.

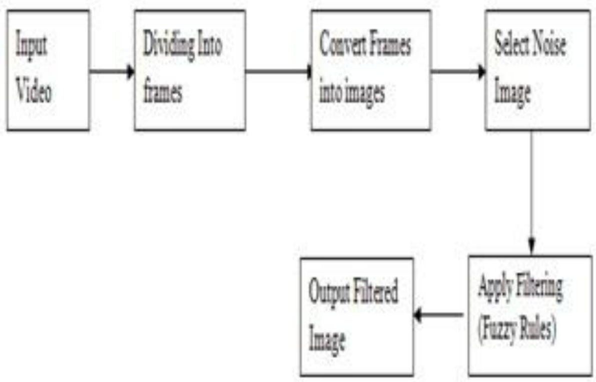

Fig1. Block diagram of proposed fuzzy filter for images

In the first step (with output denoted by I_(f_1)), we calculate for each pixel component a degree to which it is considered noise-free and a degree to which it is considered noisy. If the noisy degree is larger than the noise-free degree, the pixel component is filtered, oth-erwise it remains unchanged. The determination of both degrees is mainly based on temporal information (comparison to the corresponding pixel component in the previous frame).

Note, however, that only in non-moving areas can large temporal differences be assigned to noise. In areas where there is motion, such differences might also be caused by that motion. As a consequence, and as can be seen in Fig. 2, impulses in moving areas will not always be detected in this step.

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They can, however, be detected in the second step (outputI_(f_2)). Analogously as to the first step, again a noise-free degree and a noisy degree are calculated. However, the detection is now mainly based on color information. A pixel component can be seen as noisy if there is no similarity to its (spatio-temporal) neighbors in the given color, while there is in the other color bands.

A. First Filtering Step

Detection:

In this detection step, we calculate for each of the components of each pixel a degree to which it is considered noise-free and a degree to which it is thought to be noisy. A component for which the noisy degree is larger than the noise free degree, i.e., that is more likely to be noisy than noise-free, will be filtered. Other pixel components will remain unchanged.

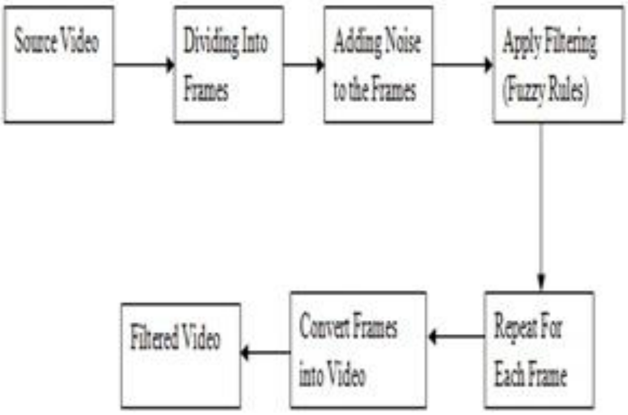

Fig2. Block diagram of proposed work for videos

The noise-free degree and the noisy degree are determined by fuzzy rules as follows.

We consider a pixel component to be noise-free if it is similar to the corresponding component of the pixel at the same spatial location in the previous or next frame and to the corresponding component of two neighboring pixels in the same frame. In the case of motion, the pixels in the previous frames cannot be used to determine whether a pixel component in the current frame is noise-free. Therefore, more confirmation (more similar neighbors or also similar in the other color components) is wanted instead. For the noise-free degree of the red component (and analogously for the other components), this is achieved by the following fuzzy rule.

IV. EXPERIMENTAL RESULTS

The experimental results have been done in MATLAB 2011a version and tested with different color image sequences and color videos also. The proposed work has been applied to a color video 'salesman.avi', and observed the denoising results in following figures. Original frame from a color video has shown in fig.1 and the noisy image which is corrupted by random impulse noise is shown in fig2. And the denoised images after successive filtering steps have been shown in fig.3 (a) first filtering output (b) second stage output and fig4 shows final filtering step output. Also calculated the Peak Signal to Noise Ratio (PSNR) and Mean Absolute Error (MAE) for the comparison of different filtering steps in terms of the visual quality of denoised images.

Fig.1. Original Frame of Input Color Video

Fig. 2. Noisy Image

(A)

(B)

Fig. 3. (a) Output of fuzzy filter after First Filtering Step (b) output of fuzzy filter after Second Filtering Step

Fig. 4. Output of final filtering Step

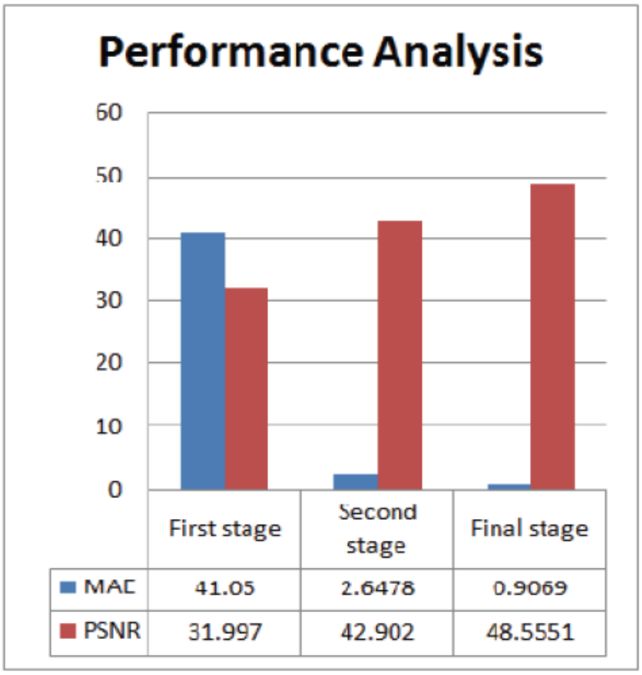

Fig. 5. Performance analysis of proposed filtering work

V. CONCLUSIONS

Here in this letter, we had presented a novel fuzzy fi ltering framework for color videos, which has been corrupted by random impulse noise. To improve the efficiency, we followed a step by step process. Noised video has been denoised in successive filtering steps using proposed fuzzy rules. The experiments showed that the proposed method outperforms other state-of-theart methods both in terms of objective measures such as MAE and PSNR and visually.

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