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Removing Impulse Random Noise from Color Video Using Fuzzy Filter

S.Sagar[1], K.Ashok Babu[2]
[1]*M.tech.Student, Sri Indu College of Engineering & Technology, Hyderabad*
[2]*Professor & HOD of ECE, Sri Indu College of Engineering & Technology, Hyderabad*

Abstract—Fuzzy filter is a filter technique for the removal of random impulse noise in color video. By working with different successive filtering steps, a very good tradeoff between detail preservation and noise removal is obtained. So, to noise is filtered step by step. In each step, noise pixels in color frame are detected using fuzzy rules, which are very useful for the processing of human knowledge where linguistic variables are used. Pixels that are detected as noisy are filtered, the others remain unchanged. The experimental results shows that the different successive filtering of one frame and calculate the image quality measurements like peak signal to noise ratio(PSNR),mean absolute error(MAE) and normalized color difference(NCD).

Index Terms—Circuits and systems, computers and information processing, computational and artificial intelligence, filtering, filters, fuzzy logic, image denoising, logic, nonlinear filters.

I. INTRODUCTION

The application of fuzzy techniques in image processing is a promising research field. Fuzzy techniques have already been applied in several domains of image processing (e.g., filtering, interpolation, and morphology), and have numerous practical applications (e.g., in industrial and medical image processing). In this project, we will focus on fuzzy techniques for image filtering. Already several fuzzy filters for noise reduction have been developed, e.g., the well-known FIRE-filter from, the weighted fuzzy mean filter from, and the iterative fuzzy control based filter from. Most fuzzy techniques in image noise reduction mainly deal with fat tailed noise like impulse noise. These fuzzy filters are able to outperform rank-order filter schemes (such as the median filter). Nevertheless, most fuzzy techniques are not specifically designed for Gaussian (-like) noise or do not produce convincing results when applied to handle this type of noise [1].

Most filters in literature that are developed for video are intended for sequences corrupted by additive Gaussian noise (e.g., [2]–[7]). Only few video filters for the impulse noise case can be found (e.g., [19]–[23]). However, several impulse noise filters for still images exist. The best known among them are the median based rank-order filters (e.g., [8]–[10]. But also some fuzzy techniques can be found [11]–[18]. Such 2-D filters could be used to filter each of the frames of a video successively. However, temporal inconsistencies will arise due to the neglect ion of the temporal correlation between successive frames. A better alternative would be to use 3-D filtering windows, in which also pixels from neighboring frames are taken into account [19]–[23]The main problem in using neighboring frames is motion between them. Using pixels at corresponding spatial positions in neighboring frames for noise removal may introduce ghosting artifacts in the presence of camera and object motion.

In this paper is organized as follows. Proposed method in section II. Section III describes the Quality measurements. The simulation results are presented in Section IV. Concluding remarks are made in Section V.

II. PROPOSED METHOD

The fuzzy filter consists of three successive filtering steps to remove the noise step by step procedure. In filtering consists of 3 steps to remove random noise as show in fig.1.

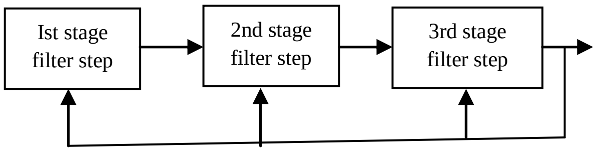

Fig.1.block diagram of proposed method

(i). First filtering step

In first 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. The outcome of the fuzzy rule, i.e., the degree to which the red component of the pixel at position (x, y, t) is considered noise-free, is determined as the degree to which the antecedent in the fuzzy rule is true:

$\mu^{R}_{noise\text{-}free}(x,y,t)=\max(\min(\max(\alpha 1(x, y, t),\alpha 2(x, y, t),M2(x, y, t),\max(M4(x, y, t),M2b(x, y, t)))));$

And where M4(x, y, t) and M2b(x, y, t) respectively denote the degree to which there are two (respectively four) neighbors for which the absolute difference in the red component value is not large positive.
The outcome of the fuzzy rule, i.e., the degree to which the red component of the pixel at position (x, y, t) is considered noisy, is determined as the degree to which the antecedent in the fuzzy rule is true:
$\mu^R_{noise}(x, y, t) = \min(\beta(x, y, t), \delta(x, y, t), \gamma(x, y, t))$
The filtering for the red color band. The filtering of the other color bands is analogous. We decide to filter all red pixel components that are considered more likely to be noisy than noise-free, i.e., for which $\mu^R_{noise}(x, y, t) > \mu^R_{noise\text{-}free}(x, y, t)$. The red components of the other pixels remain unchanged to avoid the filtering of noise-free pixels (that might have been incorrectly assigned a low noisy degree, but for which the high noise-free degree assures us that it is noise-free) and thus detail loss. On the other hand, noisy pixel components might remain unfiltered due to an incorrect high noise-free degree, but those pixels can still be detected in the next filtering step.

(ii) Second filtering step

In this step, the noise is detected based on the output of the previous step *i*. Also in this second filtering step, a degree to which a pixel component is expected to be noise-free and a degree to which a pixel component is expected to be noisy, is calculated. In the calculation of those degrees, we now take into account information from the other color bands.
The noisy degree for the red component of the pixel at position (x, y, t) is then calculated as follows:
$\mu_2{}^R_{noise}(x, y, t) = \max(\theta(x, y, t), k(x, y, t))$
Red pixel components that are considered noise-free remain unchanged i.e.
$\mu^R_{noise}(x, y, t) = \mu_2{}^R_{noise}(x, y, t);$

(iii). Third step

The result from the previous steps is further refined based on temporal, spatial and color information. Namely, the red component (and analogously the green and blue component) of a pixel is refined in the following cases:
• In non-moving areas, pixels will correspond to the pixels in the previous frame, which allows us to detect remaining isolated noisy pixels. If (x, y, t) lies in a non-moving 3 * 3 neighborhood, i.e.,
$\Delta(x, y, t) = |\mu^R_{noise}(x, y, t) - \mu_2{}^R_{noise}(x, y, t)|$

III. QUALITY MEASUREMENTS

To assess the performance of the proposed filters for removal of noise and to evaluate their comparative performance, different standard performance indices have been used in the thesis. These are defined as follows:

Peak Signal to Noise Ratio (PSNR): It is measured in decibel (dB) and for gray scale image it is defined as:

$$\text{PSNR (dB)} = 10\log_{10}\left[\frac{\sum_i\sum_j 255^2}{\sum_i\sum_j\left(S_{i,j} - \hat{S}_{i,j}\right)^2}\right] \quad (8)$$

$S_{i,j}$ and $\hat{S}_{i,j}$ are the input and reconstruction images. The higher the PSNR in the restored image, the better is its quality.
The NCD, between an original and a filtered frame, is calculated as
$NCD = \sum\sum(S_{i,j} - \hat{S}_{i,j}) / (\sum S_{i,j})$

IV. EXPERIMENTAL RESULTS

Original low resolution image

Fig.2 60th frame of the "Football"

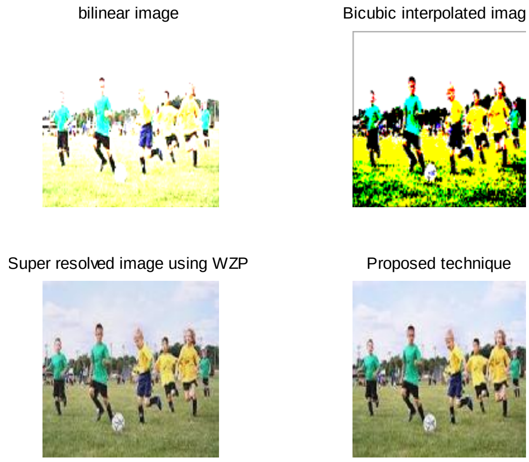

Fig.3. 60th frame of the "footbal" sequence (top-left to bottom-right): bilinear image (PSNR=27.098),Bi Cubic Interpolation Image(PSNR=28.14),WZP(PSNR=35.462),proposed method(PSNR=37.58)

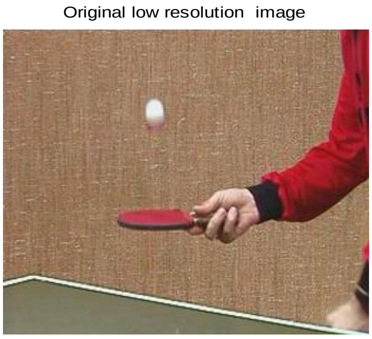

Fig.4 78th frame of the "Tennis"

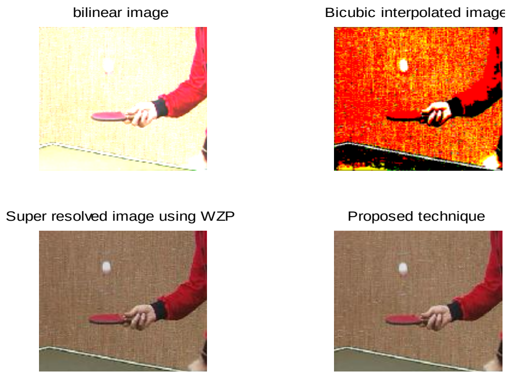

Fig.5. 110th frame of the "Tennis" sequence (top-left to bottom-right): bilinear image (PSNR=26.898),Bi Cubic Interpolation Image(PSNR=28.94),WZP(PSNR=34.4912),proposed method(PSNR=34.6301)

V. CONCLUSION

In this paper, we have presented a new filtering framework for color videos corrupted with random valued impulse noise. In order to preserve the details as much as possible, the noise is removed step by step. The detection of noisy color components is based on fuzzy rules in which information from spatial and temporal neighbors as well as from the other color bands is used. Detected noisy components are filtered based on block matching where a noise adaptive mean absolute difference is used and where the search region contains pixels blocks from both the previous and current frame.

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Mr.**S.SAGAR** graduate from Aizza College of engg & technology in **Electronics& Communications**. Now pursuing Masters in **Digital Electronics and Communication Systems** (DECS) from Sri Indu College of Engineering & Technology.

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