Denoising of a Color image using fuzzy Filtering Techniques

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Abstract— In this paper, different types of filtering techniques are used for the removal of noise in an image. The results are obtained by three steps in the filtering process. Step by step the noise is removed in a considerable amount. The noisy pixels are detected step by step with the help of Fuzzy rules and removed one by one, and the noise-free pixels are remained unchanged. Due to linguistic variables are used. The pixels that are detected as noisy is done by block-matching based on a noise adaptive mean absolute difference. The proposed method is done by measuring different methods, such as the mean absolute error (MAE), the peak signal-to-noise ratio (PSNR) and the normalized color difference (NCD), in terms of state-of-the-art filters.

Keywords—Fuzzy Filter, Image processing, Image denoising, Impulse noise, membership functions, noise reduction, block matching.

I. INTRODUCTION

Digital images are used very often in the day to day life. Some images may be fine and some may be corrupted with some distortion like noise due to disturbance, recording. So to remove the noise in the disturbed (or) distortion images we are using these fuzzy filtering techniques, where the image can be cleared and its noise free. There are different types of noises that are distinguished [1]. They are: (i) impulse noise, where a certain percentage of the pixels is replaced by a fixed value (mostly the minimum or maximum possible value) or a random value (usually from a uniform distribution), (ii) additive noise, where a random value from a certain distribution (e.g. a Gaussian distribution) is added to each pixel value and (iii) multiplicative noise, where the intensity of the noise depends on the intensity of the pixel (e.g. speckle noise)where a random value from a certain distribution. The noise is normally involved by means of a faulty medium in the case of original image. The existing noise removal filters generally have the demerits of inducing unwanted distortions and blurring effects into the resulted image during noise removal phase [2]. The block-based search technique is highly desirable to assure much reduced processing delay while maintaining good reconstructed image quality [3].

Fuzzy set theory was introduced by Zadeh in 1965 [4] and is a generalization of classical set theory. It minimizes the effect of uncertainties in rules that are based on fuzzy logic systems (FLS). A classical crisp set over a universe X can be modelled by an X-{0, 1} mapping (characteristic function): an element belongs to x ∈ X the set or does not belong to it. Fuzzy sets are now modelled as X - [0,1] mappings (membership functions). An element x ∈ X can now also belong to some degree to the set, which allows a more gradual transition between belonging to and not belonging to. Such gradual transition makes fuzzy sets very useful for the processing of human knowledge in terms of linguistic variables (e.g., large, small, etc.)[5].The effectiveness of fuzzy set theory in image processing is been preferred and can be observed in [6]. A "gray" color is one in which the red, green, and blue components all have equal intensity in the RGB space, so it is only necessary to specify one single intensity value for each pixel, as opposed to the three intensities needed to specify a pixel in a full color image. Often, the (grayscale) intensity is stored as an 8-bit integer giving 256 possible different shades of gray going from black to white, which can be represented as a [0,255] integer interval. In this interval, we consider several integer values Ƥ1, Ƥ2, ….,Ƥn with (Ƥk ≠ Ƥl) and n≤ 255. If O (i,j) denotes the pixel value of the (two-dimensional) image O at position (i,j), then we can model the occurrence of impulse noise, for grayscale images, as [7]

$$A(i,j) = \begin{cases} O(i,j) & \text{with probability } 1-pr \\ \eta(i,j) & \text{with probability } pr \end{cases}$$

$$A(i,j)=I_n^x(x,y,t);\ O(x,y,t)=I_o^x(x,y,t);$$

$$\eta(i,j) = \eta^c(x,y,t)$$

Where η(i,j) is an identically distributed, independent random process with an arbitrary underlying probability density function. In this paper, the RGB color image is been considered, which consists of red, blue and green bands. Different filtering steps are used. The noised image is to be given as the input and the following filtering steps are done, the noised image is been converted to noise free image, which is obtained as the output. Normally the image consists of pixels. Depending on the pixels of the image, the corrupted pixels are been filtered (or) replaced by different pixels by the help of the neighboring pixels (or) the same pixels in the previous frame, the noise free pixels are remained constant. The noisy pixels are only changed. The filtering is done by block-matching, technique which is used for video compression that has already been adopted in video filters for the removal of Gaussian noise [5] e.g., [8]-[10]. To avoid blurring due to the filtering of noise-free pixels, this filtering framework has been further refined by weighted filtering techniques [11], [12], [13] and switching schemes where the filter is only used for detected noisy pixels [14], [15], [16], [17], [18], The proposed methods are done by different techniques like MAE (mean absolute difference), PSNR (peak-signal-to-noise ratio) and the NCD (normalized color difference)which are outperformed.

II. THE PROPOSED ALGORITHM

The framework that is filtered presented in this paper is intended for color image is corrupted by random impulse noise. The original image (i.e., noise free) is been considered and denoted as I_o, whereas the frame is denoted as t (i.e., $I_o(t)$).The RGB color image sequence is denoted by $O(i,j)=I_o^c(x,y,t)$ and $\eta^c(i,j)= \eta(x,y,t)$.Where the denotes the row and y denotes the column and t denotes the frame. The different color bands (i.e., red, green and blue) are denoted by the above sequence $I_o^R(x,y,t)$, $I_o^G(x,y,t)$, $I_o^B(x,y,t)$.The noisy sequence is denoted as Inc where c denotes the current frame [5].

Where $c \in [R, G,B]$ and $\mathcal{P} \in [0,1]$ denotes the probability that a pixel component value is corrupted and replaced by a identically distributed independent random noise value $\eta c(x,y,t)$ coming from a uniform distribution on the interval of possible color component values [5]. The color component is corrupted varies by the neighboring pixel of the same frame and the same pixels of the previous frame. Three steps are used for the filtering in the proposed algorithm.

The noise is removed by step by step. The noise free pixels should be no larger than the noisy pixels. If this is agreed then the pixels are filtered. These determination is based on the temporal information (same pixels in the previous frame). These difference is also obtained by the motion in the areas. Step by step the pixels are calculated and the noise is been removed.

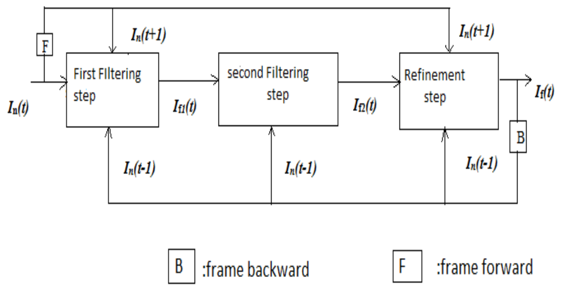


Fig.1 Block diagram of proposed algorithm

In each and every step the noisy and noise free pixels are calculated. The noisy pixels are found by the neighboring pixels of the same color component, (which is known as spatial-temporal). If there is no similarity between the neighboring pixels, then the pixels are noise-free. If the variance is obtained then they are noisy. Such that the noisy pixels can be filtered. If the noise is not filtered, the next step is used to remove these noise by comparing with the other color components.

A. *Filtering Step 1*

In these section we are detecting the noisy pixels by comparing with the noise-free pixels and the pixels that are found noisy or corrupted are filtered. Two steps are done in this process.

i. *Detection.*
ii. *Filtering*.

i. *Detection:* where each and every pixel of each component is to be calculated by. its degree whether noisy or noise-free. If suppose the noisy pixel degree is larger the noise-free pixels degree, then that pixel is identified as noisy.it should be filtered. The other pixels which are not larger are remained constant.

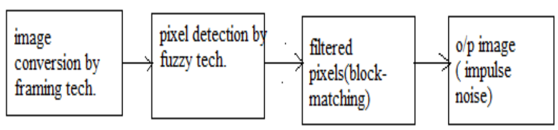


Fig.2 process of first filtering

The pixels are calculated to be noisy or noise-free from the corresponding pixels by their similarities. If the variation is too large, then they are noisy pixels. 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 [5]. The noised and noise-free pixel degrees are calculated by the Fuzzy rules. The components are calculated individually one by one for filtering the noise (i.e., red, green, blue). Based on the neighboring pixels the corrupted pixels are filtered.

0	0	0	0	0
0	0	0	0	0
-1	-1	2	-1	-1
0	0	0	0	0
0	0	0	0	0

0	0	-1	0	0
0	0	-1	0	0
0	0	2	0	0
0	0	-1	0	0
0	0	-1	0	0

-1	0	0	0	0
0	-1	0	0	0
0	0	2	0	0
0	0	0	-1	0
0	0	0	0	-1

0	0	0	0	-1
0	0	0	-1	0
0	0	2	0	0
0	-1	0	0	0
-1	0	0	0	0

Fig.3 convolution mask of pixels

Fuzzy Rule 1: If $((|I_n^R(x, y, t) - I_f^R(x, y, t-1)|$ is not large positive or $|I_n^R(x, y, t) - I_n^R(x, y, t+1)|$ is not large positive) and there are two neighbors $(x+k, y+l,t)(-2\leq k,l\leq 2)$ and $(k,l)\neq(0,0))$ for which $|I_n^R(x, y, t)- I_n^R(x+k, y+l, t)$ is not large positive)

Or(there are four neighbors $(x+k, y+l,t)(-2\leq k,l\leq 2))$ and $(k,l)\neq(0,0))$ for which $|I_n^R(x, y, t)- I_n^R(x+k, y+l, t)|$ is not large positive or(there are two neighbors $(x+k, y+l,t)(-2\leq k,l\leq 2)$ and $(k,l)\neq(0,0))$ for which $|I_n^R(x, y, t)- I_n^R(x+k, y+l, t)|$ is not large positive and which $|I_n^G(x, y, t)- I_n^G(x+k, y+l, t)|$ or $|I_n^B(x, y, t)- I_n^B(x+k, y+l, t)|$ are not large positive

Then the red component is considered to be noise-free.

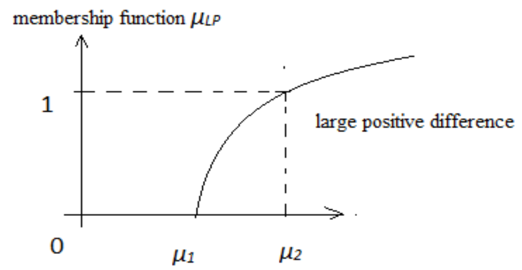


Fig.4 The membership function μ_{LP}

Where $\mu_{LP}\rightarrow$ large positive

The fig.4 mentions the membership function μ_{LP}. The value is represented as large positive only by the fuzzy rule, the membership function is used with the fuzzy set. The minimum, maximum operators and the standard negator is been used, which the results can be determined clearly and is simple. For the conformation of the pixel whether it is noisy or noise-free, the maximum value is to be calculated. For noise-free pixels in red component:

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

Where

$$\alpha 1(x,y,t) = (1-\mu_{LP}(|\, I_n^R(x, y, t) - I_f^R(x, y, t-1)|))$$

$$\alpha 2(x,y,t) = (1-\mu_{LP}(|\, I_n^R(x, y, t) - I_n^R(x, y, t+1)|))$$

and where $M_2(x,y,t)$ and $M_4(x,y,t)$ 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, that is determined as the second (respectively fourth) largest element in the set[5].

$$\{1-\mu_{LP}(|\, I_n^R(x, y, t) - I_n^R(x+k, y+l, t)|)$$

$$||\ -2\leq k,l\leq 2 \text{ and } (k,l)\neq(0,0)\}$$

and denotes the degree to which there are two neighbors for which the absolute differences in the red component and one of the two color components are not large positive. The noisy pixels are only calculated where the noise-free are remains unchanged. The pixels of neighbors of the same spatial location in the previous frames are calculated that should be large positive. The color band is also be considered if differences is un-occurred. The neighbors of both side pixels are to be verified. If there is no difference in the previous frame in the spatial location in other color bands, then the fuzzy rule is applied only for the red component

Fuzzy Rule 2: If $((|I_n^R(x, y, t) - I_f^R(x, y, t-1)$ is LARGE POSITIVE AND NOT (for five neighbors $(x+k, y+l,t)(-2\leq k,l\leq 2$ and $(k,l)\neq(0,0))$ $I_n^R(x+k, y+l, t)- I_f^R(x+k, y+l, t-1)|$ is LARGE POSITIVE AND $I_n^G(x+k, y+l, t)- I_f^G(x+k, y+l, t-1)|$ or $|I_n^B(x+k, y+l, t)- I_f^B(x+k, y+l, t-1)$ is LARGE POSITIVE)))

and ((in one of the four directions (the differences $I_n^R(x,y,t)- I_n^R(x+k,y+l,t)$ AND $I_n^R(x,y,t)- I_n^R(x-k,y-l,t)((k,l) \in \{(-1,-1),(-1,0),(-1,-1),(0,1)\})$ are both LARGE POSITIVE OR both LARGE NEGATIVE) AND the absolute difference $|\, I_n^R(x+k, y+l, t)- I_n^R(x-k,y-l,t)|$ is NOT LARGE POSITIVE) OR $(I_n^G(x,y,t)- I_f^G(x, y, t-1)|$ is NOT

LARGE POSITIVE OR $|I_n^B(x,y,t)$- $|I_n^B(x,y,t\text{-}1)$ is NOT LARGE POSITIVE))

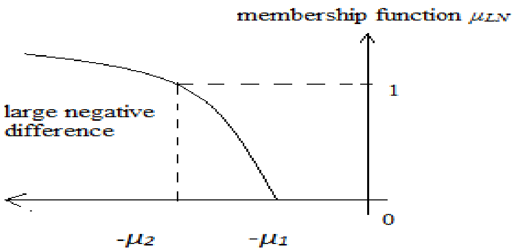
THEN the red component $I_n^R(x,y,t)$ is considered "noisy".

The fuzzy set represents the linguistic terms like large positive and large negative, which is characterized by the membership function. The differences of the current and the five neighboring pixels degree of the red component and the pixels of other two color bands are large positive are to be compared to the previous frame, where the position of the frame is denoted by t_{pos} [5].

$\{\min(\mu_{LP}(|I_n^R(x+k, y+l, t)\text{-} I_f^R(x+k, y+l, t\text{-}1)|), \max(\mu_{LP}(|I_n^G(x+k, y+l, t)\text{-} I_f^G(x+k, y+l, t\text{-}1)|), \mu_{LP}(|I_n^B(x+k, y+l, t)\text{-} I_f^B(x+k, y+l, t\text{-}1)|)))$

$\|\text{-}2\leq k,l\leq 2$ and $(k,l) \neq (0,0)$

The degree of the pixels position (x,y,t)and the same pixel position in the previous frame is large



positive and the neighbors do not have any motion.

Fig. 5 The membership function μ_{LN}

Where $\mu_{LN} \rightarrow$ large negative difference.

β (x,y,t)= min $(\mu_{LP}(|I_n^R(x, y, t)\text{-} I_f^R(x, y, t\text{-}1)|)$, 1-$t_{pos}(x,y,t))$.

The degrees of the pixel and the pixel of the previous frame (spatial location) has no more difference in the other two color bands.

δ (x,y,t) = max $(\mu_{LP}(|I_n^G(x, y, t)\text{-} I_f^G(x, y, t\text{-}1)|)$,1-$\mu_{LP}(|I_n^B(x, y, t)\text{-} I_f^G(x, y, t\text{-}1)|)))$.

The above equation shows the direction of the pixel is impulse.

And the $\gamma(x,y,t)$ is been mentioned as the maximum value in the frame.

$\{\min(\max(\varepsilon^1_{(k,l)}(x,y,t),\varepsilon^2_{(k,l)}(x,y,t)),\varepsilon^3_{(k,l)}(x,y,t))$

$\|(k,l)\in \{(-1,-1), (-1,0), (-1,1), (0,1)\}\}$

Where

$\varepsilon^1_{(k,l)}(x,y,t)$ = $\min(\mu_{LP}(I_n^R(x, y, t)\text{-}I_n^R(x+k, y+l, t)), \mu_{LP}(I_n^R(x, y, t)\text{-} I_n^R(x\text{-}k, y\text{-}l, t)))$,

$\varepsilon^2_{(k,l)}(x,y,t)$ = $\min(\mu_{LN}(I_n^R(x, y, t)\text{-} I_n^R(x+k, y+l, t)), \mu_{LN}(I_n^R(x, y, t)\text{-} I_n^R(x\text{-}k, y\text{-}l, t)))$,

$\varepsilon^3_{(k,l)}(x,y,t)$ = $1\text{-}\mu_{LP}(|I_n^R(x+k, y+l, t)\text{-} I_n^R(x\text{-}k, y\text{-}l, t)|)$.

By combining the above three equations, we get:

$\mu^R_{noise(x,y,t)}$ = $\min(\beta\ (x,y,t), \delta\ (x,y,t), \gamma(x,y,t))$.

ii *Filtering:* The filtering mainly transforms the pixel intensity values to reveal certain image characteristics that are Enhancement, Smoothing, Template matching. The filtering of red color band is done, where the other color bands filtering is analogous. Only noisy pixels are considered than the noise-free pixels (especially in the red color band). Here the noisy pixels should be greater than the noise-free pixels. If the noise-free pixels are considered, then the pixels may vary and may be corrupted. So, only the noisy pixels are been considered and again the filtering process is done. Where the unchanged pixels in the red color band are defined as:

$\mu_{unch}(x,y,t)=(\mu^R_{unch}(x,y,t),\mu^G_{unch}(x,y,t),\mu^B_{unch}(x,y,t)$

$\mu^R_{unch}(x,y,t)=$
$\begin{cases} 0, & if\ \mu^R_{2,noisy}(x,y,t) > \mu^R_{2,noise-free}(x,y,t) \\ 1, & else \end{cases}$

The above equation mentions the unchanged pixels of the current frame. These unchanged (i.e., noise-free) pixels are been observed in all the three color bands. The block matching is performed for the spatial and temporal information in the sequence. For this purpose, a mean absolute difference is to be calculated for the color components by adding the weights. i.e.

(2.W+1) x (2.W+1). Where W $\rightarrow$ general parameter.

B. *Filtering step 2*

In this step, the noisy pixels that are not modified are done in this section. The output of the previous step is given as the input and the noisy pixels are filtered.

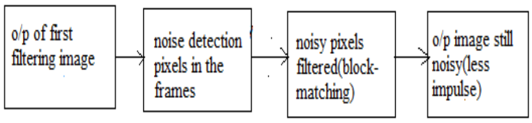


Fig. 6 process of second filtering

As we have done in the previous step, the pixels are compared with the corresponding pixels in the previous frame, if the difference between the pixels are same then they are remained constant. The pixels that varies are considered and filtered. If same they are compared with the other color bands and if variance occurs, then they are filtered.

Fuzzy Rule 3: If ($|I_{f1}^R(x, y, t)$ - $I_f^R(x, y, t\text{-}1)|$ is not large positive) AND ($|I_{f1}^G(x, y, t) - I_f^G(x, y, t\text{-}1)|$ is not large positive) or ($|I_{f1}^B(x, y, t) - I_f^B(x, y, t\text{-}1)|$ is not large positive)

Or(for two neighbors $(x+k, y+l,t)(-1\leq k,l\leq 1)$ and $(k,l)\neq(0,0)$) $|I_{f1}^R(x, y, t)\text{-} I_f^R(x+k, y+l, t)|$ is not large positive AND $|I_{f1}^G(x, y, t)\text{-} I_f^G(x+k, y+l, t)|$ is not large positive OR $|I_{f1}^B(x, y, t)\text{-} I_f^B(x+k, y+l, t)|$ is not large positive.

then the red component $I_{f1}^R(x,y,t)$ is considered "noise-free".

The pixels degree of the position (x,y,t) i.e. noise-free is:

$\mu^R_{2,\text{ noise-free}}(x,y,t) = \max(\zeta(x,y,t),\ \eta(x,y,t))$.

Where,

$\zeta(x,y,t) = \min(1\text{-}\mu_{LP}(|\ I_{f1}^R(x, y, t) - I_f^R(x, y, t\text{-}1)|),$ $\max((1\text{-}\mu_{LP}(|\ I_{f1}^G(x, y, t) - I_f^G(x, y, t\text{-}1)|),$

$1\text{-}\mu_{LP}(|\ I_{f1}^B(x, y, t) - I_f^B(x, y, t\text{-}1)|).$

And $\eta(x,y,t)$) is

{min $(1\text{-}\mu_{LP}(|\ I_{f1}^R(x, y, t) - I_f^R(x+k, y+l, t)|)$, max$((1\text{-}\mu_{LP}(|\ I_{f1}^G(x, y, t) - I_f^G(x+k, y+l, t)|),$

$1\text{-}\mu_{LP}(|\ I_{f1}^B(x, y, t) - I_f^B(x+k, y+l, t)|))).\|\ -1\leq k,l\leq 1$ and $(k,l)\neq(0,0)$}.

The noise pixels are been calculated by observing the neighboring pixels with differences in the frames. This is also considered in the color bands.

Fuzzy Rule 4: If (for three neighbors $(x+k, y+l\ t)(-1\leq k,l\leq 1)$ and $(k,l)\neq(0,0)$)) $|I_{f1}^R(x, y, t) - I_f^R(x+k, y+l, t)|$ is large positive) AND ($|I_{f1}^G(x, y, t) - I_f^G(x+k, y+l, t)|$ is not large positive) and $|I_{f1}^B(x, y, t) - I_f^B(x+k, y+l, t)|$ is not large positive)

Or(for all neighbors $(x+k, y+l,t)(-1\leq k,l\leq 1)$ and $(k,l)\neq(0,0)$) $|I_{f1}^R(x, y, t)\text{-} I_f^R(x+k, y+l, t)|$ is large positive) or (for all neighbors $(x+k, y+l,t)(-1\leq k,l\leq 1)$) and $(k,l)\neq(0,0)$) $|I_{f1}^R(x, y, t)\text{-} I_f^R(x+k, y+l, t)|$ is large negative) AND NOT (((for all neighbors $(x+k, y+l,t)(-1\leq k,l\leq 1)$) and $(k,l)\neq(0,0)$) $|I_{f1}^G(x, y, t)\text{-} I_f^G(x+k, y+l, t)|$ is large positive) OR (for all neighbors $(x+k, y+l,t)(-1\leq k,l\leq 1)$) and $(k,l)\neq(0,0)$) $|I_{f1}^G(x, y, t)\text{-} I_f^G(x+k, y+l, t)|$ is large negative)) AND ((for all neighbors $(x+k, y+l,t)(-1\leq k,l\leq 1)$) and $(k,l)\neq(0,0)$) $|I_{f1}^B(x, y, t)\text{-} I_f^B(x+k, y+l, t)|$ is large positive) OR (for all neighbors $(x+k, y+l,t)(-1\leq k,l\leq 1)$) and $(k,l)\neq(0,0)$) $|I_{f1}^B(x, y, t)\text{-} I_f^B(x+k, y+l, t)|$ is large negative)))).

THEN the red component $I_{f1}^R(x,y,t)$ is considered as "noisy".

Until now we have compared the pixels with the neighboring pixels and corresponding pixels in the previous frame by comparing the spatial and temporal information.in the filtering step 1 we have detected the pixels which are noisy and filtered and still the pixels are detected as impulse noisy. The output of the filtering step 1 is given as the input in the second filtering. Here also we are not fulfilled with the output. Still the pixels are noisy (impulse noise). In the third filtering step 3, we are totally removing the noise by giving the output of second filtering step as the input in this third filtering. We are comparing the red component and considering the noisy pixels by varying the corresponding color components.

$\mu^R_{2,\text{ noisy}}(x,y,t) = \max(\theta(x,y,t),\ k(x,y,t))$.

$\mu^R_{2,\text{unch}}(x,y,t)=$

$$\begin{cases} 0, & \text{if } \mu^R_{2,noisy}(x,y,t) > \mu^R_{2,noise-free}(x,y,t) \\ 1, & \text{else} \end{cases}$$

The above equation defines the unchanged pixels. These are calculated by comparing the both noisy and noise-free pixels. Where if the difference between the pixels are 1, then that pixels are noisy, the others are remain unchanged.

In the next step, we are using minimum mean adaptive noise for detection. Calculated for all the components of red color band. Denoted by mmad [5]. mmad(x,y,t). The unchanged pixels of red component are kept constant and the other pixels are to be filtered which has minor noise that can be done by MAD. If $\mu^R_{2,\text{ unch}}(x,y,t) = 0$, then the $I_{f1}^R(x, y, t)$ is been calculated.

C. Filtering step 3

In this step, we are providing the previous output as input to remove the noise and to make the pixels noise-free. Almost maximum percentage of error has been filtered. The remaining least percentage is been removed.

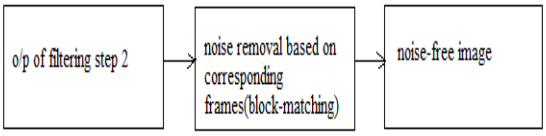


Fig. 7 process of third filtering

Normally the pixels which are not moving, that area is been concerned and made noise-free.

$$\O(x,y,t) = | I_{f2}^{c}(x, y, t) - I_{f}^{c}(x, y, t-1)|$$

.

$$\frac{\sum_{k=-1}^{1}\sum_{l=-1}^{1}\sum_{x\in\{R,G,B\}}\O(x+k,y+l,t)}{24} - \frac{\sum_{x\in\{R,G,B\}}\O(x,y,t)}{24} < \mu_1$$

In the previous filtering step, we have filtered the noisy pixels. But still the noise is obtained from the pixels in the less quantity by comparing to the corresponding frames. Here we are taking three neighbourhood pixels where we can see in the fig.3 (five neighbors).and by the neighboring pixels the red component is concerned whether larger or smaller.

$\mu R3, unch(x,y,t) = 1$.

Here the red component is said to be noise-free, if the red color band is greater than the other two color bands and should be greater than $\mu 1$. When comparing the red band to the other bands, first of all the red component should be noise-free.

As done in the previous step, the minimum value is to be done. Here we are denoting as mmad2(x,y,t).

Finally the red component is filtered and concerned as noise-free.

$$I_f^R(x, y, t) = I_{f2}^R(x, y, t).$$

D. State of art filters

There are some other state of art filters that are used for image denoising like adaptive vector median filter [14] and video adaptive vector directional median filter with 3-D filtering window [19]. The conventional techniques of adaptive median filtering are 2-D 3×3 median filtering, 3-D median filtering, 2-D 3×3 weighted median filtering [21], 2-D two-state Median filtering [20] and 3-D weighted median filtering [21]. The LUM-smoother algorithm of course preserves the details but it cannot be done at high level noises. The histogram adaptive fuzzy filter uses the histogram of an image.

III. Simulation Results

Here we are calculating the MAE, PSNR, and NCD for the corresponding frames.

The MAE is calculated as

$$MAE\,(I_o(t), I_f(t)) = \frac{\sum_{c\in\{R,G,B\}}\sum_{x=1}^{m}\sum_{y=1}^{n}|c-d|}{3.n.m}$$

Where $I_o(t)$ and $I_f(t)$ are the current and the previous frames. c represents $I_o^c(x,y,t)$ and d represents $I_f^c(x,y,t)$.

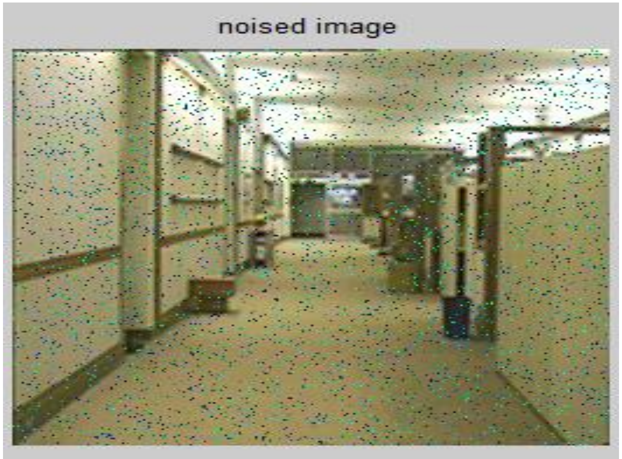
$$MSE(I_o(t),I_f(t))=\frac{\sum_{c\in\{R,G,B\}}\sum_{x=1}^{m}\sum_{y=1}^{n}(c-d)^2}{3.n.m}$$

$$PSNR(I_o(t),I_f(t))=10.\log10\frac{s^2}{MSE(Io(t),If(t))}$$

S=255,The max. value pixel of an image.

The NCD is calculated as

$$NCD(I_o(t),I_f(t))=\frac{\sum_{x=1}^{m}\sum_{y=1}^{n}\left\|I_o^{LAB}(x,y,t)-I_f^{LAB}(x,y,t)\right\|}{\sum_{x=1}^{m}\sum_{y=1}^{n}\left\|I_o^{LAB}(x,y,t)\right\|}$$



(a)

(b)

(c)

(d)

Fig.8 output images step by step

The MAE and PSNR values that are determined at the 10th frame while simulation:

Filters	**MAE**	**PSNR**
First filtering	41.6428	31.9354
Second filtering	6.2570	40.1671
Final filtering	3.5164	42.6698

Table 1. MAE and PSNR values of 10th frame

IV. CONCLUSION

We have discussed filtering steps how the noise is to be filtered in the corrupted images. Step by step the noise is filtered completely by comparing the neighboring pixels and the pixels in the corresponding frames. The results shows how the noise has been removed step wise.

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REFERENCES

[1] Tom Mélange, Mike Nachtegael, Stefan Schulte, Etienne E. Kerre., Fuzziness and Uncertainty Modelling Research Unit, Department of Applied Mathematics and Computer Science, Ghent University, Krijgslaan 281 (Building S9), 9000 Ghent, Belgium., A fuzzyfilter for the removal of random impulse noise in image sequences.,ELSEVIER publications.

[2] V.Saradhadevi, Dr.V.Sundaram, Karpagam University.,An Adaptive Fuzzy Switching Filter for Images Corrupted by Impulse Noise., Global Journal of Computer Science and Technology .,Volume 11 ,Issue 4 ,Version 1.0., March 2011.

[3] Shan Zhu and Kai-Kuang Ma., A New Diamond Search Algorithm for Fast Block-Matching Motion Estimation., IEEE transactions on image processing, vol. 9, no. 2, february 2000.

[4] L. A. Zadeh, "Fuzzy sets," Information and Control, vol. 8, pp. 338–353, 1965.

[5] Tom Mélange, Mike Nachtegael, and Etienne E. Kerre., Fuzzy Random Impulse Noise Removal From Color Image Sequences., IEEE transactions on image processing, vol. 20, no. 4, April 2011.

[6] E. Kerre and M. Nachtegael, Eds., "Fuzzy techniques in image processing," inStudies in Fuzziness and Soft Computing. Heidelberg, Germany: Physica-Verlag, 2000, vol. 52.

[7] Stefan Schulte, Mike Nachtegael, Valérie De Witte, Dietrich Van der Weken, and Etienne E. Kerre., A Fuzzy Impulse Noise Detection and Reduction Method., IEEE transactions on image processing, vol. 15, no. 5, may 2006.

[8] L. Jovanov, A. Pizurica, V. Zlokolica, S. Schulte, P. Schelkens, A. Munteanu, E. E. Kerre, and W. Philips, "Combined wavelet-domain and motion-compensated video denoising based on video codec mo-tion estimation methods," IEEE Trans. Circuits Syst. Video Technol., vol. 19, no. 3, pp. 417–421, 2009.

[9] H. B. Yin, X. Z. Fang, Z. Wei, and X. K. Yang, "An improved mo-tion-compensated 3-D LLMMSE filter with spatio-temporal adaptive filtering support,"IEEE Trans. Circuits Syst. Video Technol., vol. 17, no. 12, pp. 1714–1727, 2007.

[10] L. Guo, O. C. Au, M. Ma, and Z. Liang, "Temporal video denoising based on multihypothesis motion compensation,"IEEE Trans. Circuits Syst. Video Technol, vol. 17, no. 10, pp. 1423–1429, 2007.

[11] R. Lukac, "Adaptive color image filtering based on center-weighted vector directional filters,"Multidimen. Syst. Signal Process, vol. 15, no. 2, pp. 169–196, 2004.

[12] S. J. Ko and Y. H. Lee, "Center weighted median filters and their ap-plications to image enhancement,"IEEE Trans. Circuits Syst., vol. 38, pp. 984–993, 1991.

[13] J.-S. Kim and H. W. Park, "Adaptive 3-D median filtering for restoration of an image sequence corrupted by impulse noise,"Signal Process.: Image Commun., vol. 16, pp. 657–668, 2001.

[14] R. Lukac, "Vector order-statistics for impulse detection in noisy color image sequences," in Proc. 4th EURASIP-IEEE Region 8 Int. Symp. Video/Image Process. Multimedia Commun., Zadar, Croatia, 2002.

[15] R. Lukac, "Adaptive vector median filtering,"Pattern Recognit. Lett, vol. 24, pp. 1889–1899, 2003.

[16] R. Lukac, K. N. Plataniotis, A. N. Venetsanopoulos, and B. Smolka, "A statistically-switched adaptive vector median filter,"J. Intell. Robot. Syst., vol. 42, no. 4, pp. 361–391, 2005.

[17] Z. H. Ma, H. R. Wu, and B. Qiu, "A robust structure-adaptive hybrid vector filter for color image restoration,"IEEE Trans. Image Process., vol. 14, no. 12, pp. 1990–2001, 2005.

[18] S. Morillas, V. Gregori, G. Peris-Fajarns, and P. Latorre, "A fast impulsive noise color image filter using fuzzy metrics,"Real-Time Imag., vol. 11, no. 5–6, pp. 417–428, 2005.

[19] V. Ponomaryov, A. Rosales-Silva, and V. Golikov, "Adaptive and vector directional processing applied to video colour images,"Elec-tron. Lett., vol. 42, no. 11, pp. 623–624, 2006.

[20] E. Abreu, M. Lightstone, S.K. Mitra, K. Arakawa, A new efficient approach for the removal of impulse noise from highly corrupted images, IEEE Trans. Image Process. 5 (6) (June 1996) 1012}1025.

[21] M.I. Sezan, R.L. Lagendijk, Motion Analysis and Image Sequence Processing, Kluwer Academic Publishers, Mass-achusetts, 1993.