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Mixed-Noise Reduction by Using Hybrid (Fuzzy & Kalman) Filters For Gray and Color Images

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Abstract

Removing or reduction mixed noise that corrupted image is very active environment research area in image processing. In this paper a hybrid filter that combine the advantage of fuzzy classical filter and median filter with Kalman filter are suggested, the hybrid filters can be reducing the effect of mixed noise(Gaussian and salt-pepper) noise with different level densities for two type gray and color images. The first sub two filters(fuzzy classical filter and median filter)are reducing the salt -peppers noise, while the second sub filter (Kalman filter) reducing the Gaussian noise and the final output from the last has updated (modify) the central pixel of the noisy image window 3*3 in recursive model. Comparative result of the hybrid filter with the conventional reduction filter such as mean, Median, single Kalman filter, the asymmetrical triangular fuzzy filters with median center (ATMED), the symmetrical triangular fuzzy filter with median center (TMED), and median rational hybrid filter are done by using Matlab with numerical measurement signal to noise ratio (SNR) and mean square error (MSE) to explain the performance of this filtering technique.

الخلاصة

إزالة أو تقليل الضوضاء المختلطة في الصور لها بيئة بحث نشطة في مجال معالجة الصور .في هذا البحث تم اقتراح مرشح مشترك(مركب) يجمع بين محاسن المرشح الغامض مع مرشح المعدل الوسطي مع مرشح كالمان,هذا المرشح المشترك يمكن ان يقلل من الضوضاء المختلطة في الصور الملونة والرمادية .الجزء الاول من المرشح المشترك(المرشح الغامض مع مرشح المعدل الوسطي) يزيل الضوضاء من نوع(الملح والفلفل)في حين أن المرشح الثاني (مرشح كالمان) يقلل من الضوضاء الجمعية والناتج النهائي من الاخير(مرشح كالمان) يقوم بتحديث (تعديل)البكسل المركزي لل صورة المشوشة ذات نافذة بابعاد 3 * 3 .تم عمل مقارنة بين النتائج للمرشح المشترك وبقية المرشحات التقليدية لتوضيح اداء هذا المرشح في التقليل من الضوضاء المختلطة وذلك باستخدام MATLAB مع مقياس نسبة الاشارة الى الضوضاء (SNR)ومتوسط مربع الخطأ (MSE).

Key word: additive noise, salt & pepper, mixed noise, fuzzy classical filter, kalman filter.

1. Introduction

With the development of computer science, the information and abilities of computer grow up quickly day by day. Image processing play an important role in science, medical, aerospace, industry, military, and communication and so on [1]. Reduction of noise in images is one of the most basic image processing operations [2]. Recently many filters have been designed to reduce or remove noise of corrupted images but most of them deal with only one type of noise and usually do not perform well in other noise conditions. The filters are two type linear and nonlinear filters, linear filters such as mean & Wiener filter do their best when only one type of noise is present usually Gaussian noise. Non-linear filters such as the median filters or the order static filters retain edge information but are most effective at removing impulsive noise [3-4]. The algorithms used for noise reduction mainly depend on the types of noise in images [5]. For example in Image acquisition step, the photoelectric sensor induces the white

Gaussian noise due to the thermal motion of electron is present. Many filters can be used to remove this type of noise, the most famous one is Wiener filter &mean filter. On the other hand, with the instable transferring of network some image data may be lost and salt and pepper noise is combined into the image. To remove the salt and pepper noise, many filters are designed a simple and effective one is the median filter. In many applications, these two types of noise are presented in the image together named as mixed noise. There are many mixed noise removal methods presented in the recent literature. In [6], "A Hybrid Filter For The Cancellation Of Mixed Gaussian Noise And Salt And Pepper Noise". In [7], "Mixed Noise Correction In Gray Images Using Fuzzy Filters". In [8]," Median-Rational Hybrid Filters ". In [9], "Fuzzy Filters To The Reduction Of Impulse And Gaussian Noise in Gray and Color Images".

A Linear filtering techniques used for noise reduction in images are characterized by mathematical simplicity and can effectively reduce noise. Moving average filters can smooth random noise, but they cannot suppress salt and pepper noise and cannot preserve sharp edges of an image. In such situations, various nonlinear filters based on classical and fuzzy techniques have emerged in the past few years for this task. Depending on their filtering strategies, these filters can be classified as classical filters, classical-fuzzy filters, and fuzzy filters, [10-15]. Of the many filters presented, most of them are only for gray scale images we know that filtering techniques developed for gray scale images can be extended to color images by applying it to the different color components separately but it is also evident that they can partially destroy image details. A digital color image *C* can be represented in different color space such as RGB, HSV, L*a*b etc. In the proposed method, RGB space is used as the basic color space in different proportions of red, green and blue light, in the range 0 to *2m-1*, where *m*=8. A color image *C* can be represented by a *2-D* array of vectors where (i, j) defines a position in *C* called pixel and Ci,j,1, Ci,j,2, and Ci,j,3, denotes the red, green and blue components, respectively[16], gives a wide range of colors. In the literature there are many methods available to remove salt and pepper noise in gray scale images but very little has been done for the removal of Gaussian noise in color images [17]. Here the hybrid filtering suggested for reduction of mixed noise (Gaussian and salt & pepper) in gray and color images. Two- fuzzy classical filters are defined and their filtering performance hybrids with Kalman filter to reduction mixed noise are presented.

1. Modeling Noise Of The Image

2.1 Additive Noise

Let $\mathrm{I(x,y)}$be the noisy digitized version of the ideal image F(x,y) and n(x,y)be a "noise Function", which returns random values coming from an arbitrary distribution. Then additive noise can be described by Equation

$$\mathrm{I(x,y)} = \mathrm{F(x,y)} + \mathrm{n(x,y)}$$

Additive noise is independent of the pixel values in the original image. Typically, is symmetric about zero. This has the effect of not altering the average brightness of the image, or large parts thereof, additive noise is a good model for the thermal noise within Photo-electronic sensors [18].

2.2 Impulse Noise

Impulse noise has the property of either leaving a pixel unmodified with probability 1-*p*, or replacing it altogether with probability *p*, this is shown in Equation. Restricting $\mathrm{n(x,y)}$ to producing only the extreme intensities 0 or 255 results in salt-pepper noise. The source of salt-pepper noise is usually the result of an error in transmission or an atmospheric performance-made disturbance [18].

$$\mathrm{I(x,y)} = \begin{cases} \mathrm{n(x,y)} \text{ with propapilty } & p \\ \mathrm{F(x,y)} \text{ with prpapilty } & 1-p \end{cases}$$

2.3 Mixed Noise

In general the mathematical representations for the original image and the mixed noisy image with additive white Gaussian and salt-pepper noise can be modeled as follows [19].

Original image model

$$g(i,j) = ØF(i,j) + w(i,j) \qquad ...(1)$$

Noisy image model

$$x(i,j) = g(i,j) + v1(i,j) + v2(i,j) \quad ...(2)$$

Where

Ø State transition scalar

$F(i,j)$ Denotes the pixel at the *ith* row and *jth* column of the original image.

$w(i,j)$ Is the process additive white noise uncorrelated with *v1* and *v2* with mean zero and variance $Q(i,j)$

v1 Is the additive white noise with mean zero and variance Q^2 .

v2 Is the additive impulse noise with noise density *D*.

3. Denoising By Fuzzy Filters

In this section, we concern in two of seven fuzzy filters and their filtering performance has been presented in [26]. Each of these fuzzy filters applies a weighted membership function to an image within a window to compute the value of the center pixel, it's easy and fast to implement and can suppress low, medium, and high levels of (salt-pepper and Gaussian) noise with a varying degree of success.

Let $x(i,j)$ (contaminated by mixed noise) be the input o f a 2-dimensional fuzzy filter, the output of the fuzzy filter is defined as [20].

$$y(i,j) = \frac{\sum_{(r,s)\in A} F[I(i+r,j+s)].I(i+r,j+s)}{\sum_{(r,s)\in A} F[I(i+r),j+s)]} \quad ...(3)$$

$F[I(i,j)]$ is the general window function and A is the area of the Window. For a square window of dimensions NxN, the range of *r* And *s* are [-*R* < *r* < *R* and -S < s < S], where *N* = *2R+1* = *2S+1*. With the definitions of different window functions, seven fuzzy filters are obtained [20, 21]. We concern with two type of filter, which we shall call the symmetrical triangular fuzzy filter with median center (TMED) and the asymmetrical triangular fuzzy filter with median center (ATMED).

3.1 The Symmetrical Triangular Fuzzy Filter With Median Center (TMED)

The symmetrical triangular fuzzy filter with the median value within a window chosen as the center value is defined as [21]

$$F_{tmed}[\mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s})] = \begin{cases} 1 - \dfrac{|\mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s}) - \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j})|}{\mathrm{I}_{\mathrm{mm}}(\mathrm{i},\mathrm{j})} \\ \text{for} |\mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s}) - \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j})| \leq \mathrm{I}_{\mathrm{mm}}(\mathrm{i},\mathrm{j}) \\ 1_{\text{for } \mathrm{I}_{\mathrm{mm}}} = 0 \end{cases} \quad \dots (4)$$

Where$\mathrm{I}_{\mathrm{mm}}(\mathrm{i},\mathrm{j}) = \max[\mathrm{I}_{\max}(\mathrm{i},\mathrm{j}) - \mathrm{I}_{\min}(\mathrm{i},\mathrm{j})]$ $\mathrm{I}_{\min}(\mathrm{i},\mathrm{j}), I_{\max}(\mathrm{i},\mathrm{j}), \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j})$ are respectively the minimum value, the maximum value, and the median value of all the input values $\mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s})$ for r , s ϵ A within the window A at discrete indexes (i,j).

3.2 The Asymmetrical Triangular Fuzzy Filter with Median Center (ATMED)

The asymmetrical triangular fuzzy filter with the median value within a window chosen as the center value is defined as [21]

$$F_{atmed}[\mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s})] = \begin{cases} 1 - \dfrac{\mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j}) - \mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s})}{\mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j}) - \mathrm{I}_{\min}(\mathrm{i},\mathrm{j})} \\ \text{for } \mathrm{I}_{\min}(\mathrm{i},\mathrm{j}) \leq \mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s}) \leq \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j}) \\ 1 - \dfrac{\mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s}) - \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j})}{\mathrm{I}_{\max}(\mathrm{i},\mathrm{j}) - \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j})} \\ \text{for } \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j}) \leq \mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s}) \leq \mathrm{I}_{\max}(\mathrm{i},\mathrm{j}) \\ 1 \\ \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j}) - \mathrm{I}_{\min}(\mathrm{i},\mathrm{j}) = 0 \\ \mathrm{I}_{\max}(\mathrm{i},\mathrm{j}) - \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j}) = 0 \end{cases} \quad \dots (5)$$

The triangle window function in Equation is asymmetrical. The degree of asymmetry depends of the difference between

$\mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j}) - \mathrm{I}_{\min}(\mathrm{i},\mathrm{j})$ and $\mathrm{I}_{\max}(\mathrm{i},\mathrm{j}) - \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j})$, $\mathrm{I}_{\min}(\mathrm{i},\mathrm{j}), \mathrm{I}_{\max}(\mathrm{i},\mathrm{j}), \mathrm{I}_{\mathrm{med}}(\mathrm{i},\mathrm{j})$

are respectively, the minimum value, the maximum value, and the median value of all the input values $\mathrm{I}(\mathrm{i}+\mathrm{r},\mathrm{j}+\mathrm{s})$ for r , s ϵ A within the window A at discrete indexes (i,j).

4. Denoising By Kalman Filter

The Kalman filter is a group of mathematical equations that provides an efficient computational (recursive) means to estimate the state of a process, in a way that minimizes the mean of the squared error. The filter is very powerful in several aspects, it supports estimations of past, present, and even future states. Applying 2D Kalman filter to image noise reduction have begun by Woods and continued with Angwin and Kaufman [22]. Traditionally, Kalman filter is use to estimate motion images, which is named as stacks, restoration, however, in this suggest it has been used to remove noises from still images. The Kalman filter is an estimator both to determine noise and remove it from image. The Kalman filter estimates a process by using a form of feedback control, the filter estimates the process state at some time and then obtains feedback in the form of (noisy) measurements [23]. The equations for the Kalman filter fall into two groups' time update equations, measurement update equations.

The time update equations are responsible for projecting forward (in time) the current state and error covariance estimates to obtain the a priori estimates for the next time step. The measurement update equations are responsible for the feedback. for incorporating a new measurement into the a priori estimate to obtain an improved a posteriori estimate. The time update equations can also be thought of as predictor equations, while the measurement update equations can be thought of as corrector equations. Indeed the final estimation algorithm resembles that of a predictor-corrector algorithm for solving numerical problems as shown below in Fig. (1).

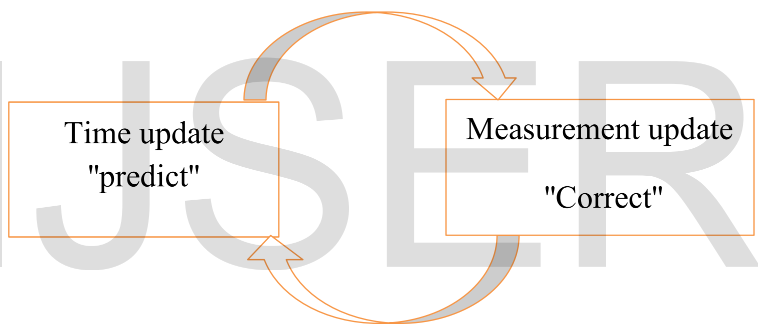

Fig.(1)The discrete Kalman filter cycle, the time update projects the current state estimate ahead in time, the measurement update adjusts the projected estimate by an actual measurement at that time.

Posteriori estimates used to project or predict the new a priori estimates. This recursive nature is one of the very appealing features of the Kalman filter, it makes practical implementations much more feasible than (for example) an implementation of a Wiener filter [27], which is designed to operate on all of the data directly for each estimate. The Kalman filter instead recursively conditions the current estimate on all of the past measurements.In general the specific equations for the time and measurement updates the Kalman filter equation (recursive) for image at *ith* row and *jth* Colum for single pixel express as given in Fig.(2)

Time update ("predict")	Measurement updates ("correct")
(1) Project the state ahead $\hat{x}(i,j) = A\overline{x}(i,j) \quad (6)$ (2) Project the error covariance ahead $\hat{p}(i,j) = A\overline{p}(i,j)A^T + Q(i,j) \ldots (7)$	(1) Compute the Kalman gain $k(i,j) = \hat{p}(i,j)[p(i,j) + \sigma\text{^}2]^{-1} \quad \ldots (8)$ (2) Update estimate with measurement z_x $\overline{x}(i,j) = \hat{x}(i,j) + k(i,j)[z(i,j) - \hat{x}(i,j)] \ldots (9)$ (3) Update the error covariance $\overline{p}(i,j) = [1 - k(i,j)]\hat{p}(i,j) \quad \ldots (10)$

Initial estimates for $\hat{x}(i,j)$and $\hat{p}(i,j)$

Fig. (2). A complete picture for operation of the Kalman filter, combining the high-level diagram of Fig. (1) With the equations.

Where :-

A state tranciton scalar

$z(i,j)$ Measurement

R Measurement noise covariance

$Q(i,j)$ Process noise covariance

$k(i,j)$ Kalman gain

$\overline{x}(i,j)$ A priori state estimate(predicated)

$\hat{x}(i,j)$ A posteriori state estimate(final o/p)

$\overline{p}(i,j)$ A priori error covariance

$\hat{p}(i,j)$ A posteriori error covariance

5. The Suggested Hybrid Filter

In the present work a simple filter is proposed to denoise mixed noise in gray and color images , the two type fuzzy classical filter (The symmetrical triangular fuzzy filter with median center (TMED), The asymmetrical triangular fuzzy filter with median center (ATMED), Operating each of one with Kalman filter After picture that contaminated with mixed noise(Gaussian & salt-pepper)noise received, we take window of size 3*3 sliding over all the noisy image and first applying median filter, then we calculate the value of fuzzy filter (ATMED or TMED). The first median filter and the second the fuzzy filter which be consider two i/p to kalman filter in parallel at the same time to the predicate and observed state respectively and the final output from kalman filter will be back in recursive model for enhance the noisy image window and this explain the adaptive factor for kalman filter. The operation for the suggested filter can be clarified by the block diagram Fig (3) and the same Kalman filter equation but with some modifications. If

1) The median filter is used to obtain the predicted state of the Kalman filter.
2) The fuzzy classical filter is used to obtain the observer state of the Kalman filter that is needed to calculate the final o/p Then :

$\overline{x}(\mathrm{i,j}) = \text{median filter of predication stste}$
$\mathrm{y(i,j)} = \text{fuzzy filter of obsereved state}$
$z(i,j) = y(i,j)$

And By assume A=1 state transition scalar, Then The kalman filter equation after modification become

$$\hat{x}(i,j) = \overline{x}(i,j) \quad \text{... (11)}$$
$$\hat{p}(i,j) = \hat{p}(i,j) + Q(i,j) \quad \text{... (12)}$$
$$k(i,j) = \hat{p}(i,j)[\hat{p}(i,j) + \sigma^{2}(i,j)]^{-1} \quad \text{... (13)}$$
$$\overline{x}(i,j) = \hat{x}(i,j) + k(i,j)[z(i,j) - \hat{x}(i,j)] \quad \text{... (14)}$$
$$\overline{p}(i,j) = [1 - k(i,j)]\hat{p}(i,j) \quad \text{... (15)}$$

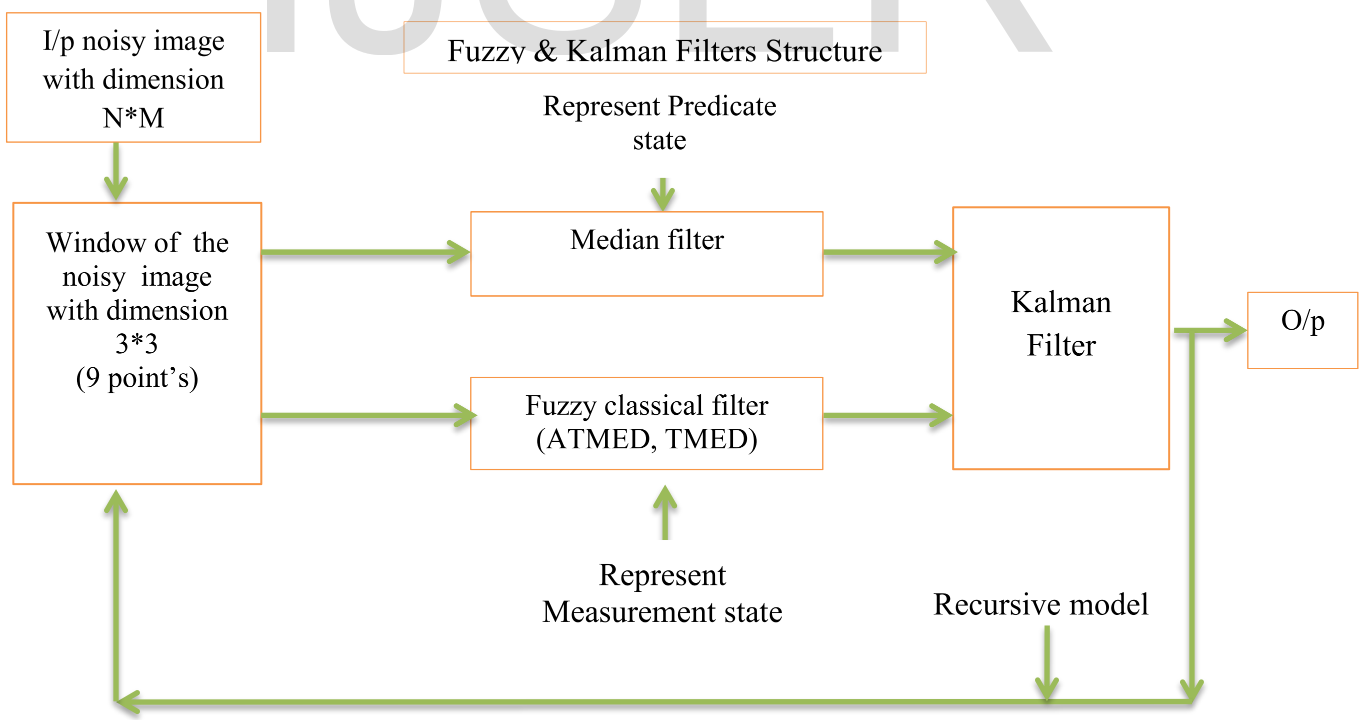

Fig. (3)The block diagram of the Hybrid suggested filter

6. Simulation Result

The performance of suggested hybrid filters have been evaluated and compared with conventional filters dealing with additive noise, salt-pepper, using MATLAB. In this section some examples of images (gray &colored images) contaminated by mixed noise (Gaussian and salt-pepper noise),the first (gray image)is 256*256 of "camera man " as shown in Fig(4), and the second (color image)is512*5102 of "child" as shown in Fig(5). As a measure of objective dissimilarity between a filtered image and the original one, we use the mean square error (MSE) and the signal to noise ratio (SNR) in decibels [24, 25].

For gray image the MSE & SNR are

$$\mathrm{MSE(Org, Img)} = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}[\mathrm{Org}(i,j) - \mathrm{Img}(i,j)]^2}{N * M} \quad \ldots (16)$$

$$\mathrm{SNR(Org, Img)} = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}[\mathrm{Org}(i,j)]^2}{\mathrm{MSE(Org, Img)}} \quad \ldots (17)$$

And for color image the MSE & SNR Become

$$\mathrm{MSE(Org, Img)} = \frac{\sum_{c=1}^{3}\sum_{i=1}^{N}\sum_{j=1}^{M}[\mathrm{Org}(i,j) - \mathrm{Img}(i,j)]^2}{3 * N * M} \quad \ldots (18)$$

$$\mathrm{SNR(Org, Img)} = \frac{\sum_{c=1}^{3}\sum_{i=1}^{N}\sum_{j=1}^{M}[\mathrm{Org}(i,j)]^2}{\mathrm{MSE(Org, Img)}} \quad \ldots (19)$$

Where org is the original image, img is the filtered image of size N*M , Table (1), (2), (3)and (4), respectively summarize the result of computer simulation to restore the gray "cameraman image" and colored "child" image which corrupted by mixed noise (Gaussian and salt- pepper noise)with different density. Simple note must be clear when using the median rational hybrid filter for comparative we replacing the center weighted median filter in the equation for the mentioned filter by median filter.

Table (1)
Comparative Result In SNR Of Different Filtering Methods For Various Distortion Of Mixed Noise For The Gray Camera Man Image (256*256)

Noise / Filters	Gau:0.01 Salt&pe:0.05	Gau:0.05 Salt&pe:0.1	Gau:0.05 Salt&pe:0.2	Gau:0.1 Salt&pe:0.4	Gau:0.2 Salt&pe:0.6
Noisy image	**10.5414**	**6.1092**	**4.5823**	**2.1725**	**0.7624**
Median	18.2910	13.4026	12.1525	7.0491	3.0749
Mean	16.8569	13.3672	11.7925	8.9071	6.8562
Kalman-only	14.0589	11.3453	10.4189	8.2580	6.4324
Fuzzy-ATMED	17.7103	13.7233	12.6041	8.6360	5.0812
Fuzzy-TMED	16.3192	13.1439	11.9678	8.9251	6.5970
Median-Rational Hybrid Filters	18.6904	13.2316	11.6764	7.3458	4.1045
Hybrid Proposed(ATMED&Kalman)	**18.7443**	**15.8175**	**15.0412**	**11.6216**	**7.6742**
Hybrid Proposed(TMED&Kalman)	**18.6504**	**15.7993**	**15.1129**	**11.5258**	**7.6874**

Table (2)
Comparative Result In MSE Of Different Filtering Methods For Various Distortion Of Mixed Noise For The Gray Camera Man Image (256*256)

Noise / Filters	Gau:0.01 Salt&pe:0.05	Gau:0.05 Salt&pe:0.1	Gau:0.05 Salt&pe:0.2	Gau:0.1 Salt&pe:0.4	Gau:0.2 Salt&pe:0.6
Noisy image	**0.0240**	**0.0666**	**0.0934**	**0.1645**	**0.2279**
Median	0.0040	0.0124	0.0165	0.0536	0.1371
Mean	0.0056	0.0125	0.0180	0.0349	0.0560
Kalman-only	0.0107	0.0199	0.0247	0.0406	0.0618
Fuzzy-ATMED	0.0038	0.0115	0.0149	0.0372	0.0843
Fuzzy-TMED	0.0063	0.0152	0.02896	0.0348	0.0912
Median-Rational Hybrid Filters	0.0037	0.0129	0.0185	0.0501	0.1056
Hybrid Proposed(ATMED&Kalman)	**0.0036**	**0.0071**	**0.0085**	**0.0183**	**0.0371**
Hybrid Proposed(TMED&Kalman)	**0.0037**	**0.0071**	**0.0084**	**0.0191**	**0.0463**

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Table (3)
Comparative Result in SNR of Different Filtering Methods for Various Distortion of Mixed Noise For The color child image (512*512)

Noise / Filters	Gau:0.005 Salt&pe:0.05	Gau:0.05 Salt&pe:0.1	Gau:0.1 Salt&pe:0.2	Gau:0.2 Salt&pe:0.4	Gau:0.3 Salt&pe:0.6
Noisy image	**13.1542**	**7.9879**	**5.5607**	**3.4486**	**2.4058**
Median	26.0970	16.1422	12.2732	7.3777	4.4093
Mean	22.2248	16.4239	13.1798	10.0620	8.1977
Kalman-only	19.2793	14.5829	12.4675	9.9793	8.1461
Fuzzy-ATMED	26.3205	16.6794	13.1017	8.5248	4.6958
Fuzzy-TMED	18.4676	14.1437	11.4475	8.5235	6.4537
Median-Rational Hybrid Filters	25.6871	15.9559	12.2712	8.0165	5.5304
Hybrid Proposed (ATMED&Kalman)	**28.8652**	**21.0842**	**17.8333**	**13.7303**	**9.8865**
Hybrid Proposed (TMED&Kalman)	**21.3786**	**20.0002**	**17.2841**	**12.9297**	**8.9824**

Table (4)
Comparative Result in MSE of Different Filtering Methods for Various Distortion of Mixed Noise For The color child image (512*512)

Noise / Filters	Gau:0.005 Salt&pe:0.05	Gau:0.05 Salt&pe:0.1	Gau:0.1 Salt&pe:0.2	Gau:0.2 Salt&pe:0.4	Gau:0.3 Salt&pe:0.6
Noisy image	**0.0203**	**0.0668**	**0.1167**	**0.1899**	**0.2414**
Median	0100.0	0.0102	0.0249	0.0768	01.100
Mean	0.0025	0.0096	0.0202	0.0414	0.0636
Kalman-only	0.0050	0.0146	0.0238	0.0422	0.0644
Fuzzy-ATMED	9.8008e-004	0.0090	0.0206	0.0590	0.1425
Fuzzy-TMED	0.0950	0.0590	0.0301	0.0162	0.0060
Median-Rational Hybrid Filters	0.0034	010000	0.0747	0.1990	010100
Hybrid Proposed(ATMED&Kalman)	**5.4550e-004**	**0.0033**	**0.0069**	**0.0178**	**0.0431**
Hybrid Proposed(TMED&Kalman)	**0.0031**	**0.0042**	**0.0079**	**0.0214**	**0.0531**

From previous tables, it's obviously to see overcoming the suggested hybrid filter performance comparative with the behaviors of sex filters and their filtering action, each of these sex filters execute reduction of the mixed noise in image but with low degree and noticeable the decreasing performance when the noise level increase while the suggested hybrid filter bestow good effect when the level noise increase, in other word's the capability of hybrid filter under high level noise it's best according to the capability of the other filter comparatives. The suggested hybrid filter can suppress low, medium, and high levels of impulse noise (salt pepper noise) and Gaussian noise with a varying degree of success. Depend on the features of an image, the performance of each of these two suggested hybrid filters varies slightly, and do well with the two types gray and color image.

7. Conclusion

A hybrid filter for restoring gray and color images corrupted with mixed noise is proposed in this paper. The proposed filter is hybrid the fuzzy classical filter and median filter as two input for kalman filter and the output of the last be used to update central pixel of noisy image window3*3. Computer simulation with two different image (gray and color) explain that hybrid filter is efficient than conventional filters mentioned in this paper mean, median , single Kalman filter, ATMED filter, TMED filter, and median rational hybrid filter.

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