FORM 1 THE PATENTS ACT, 1970 (39 of 1970) & THE PATENTS RULES, 2003 APPLICATION FOR GRANT OF PATENT [See sections 7, 54 & 135 and rule 20(1)]	(FOR OFFICE USE ONLY) Application No.: .... Filing Date: .... Amount of Fee Paid: .... CBR No.: .... Signature: ....

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3. TITLE OF THE INVENTION: **A System for Noise Reduction in Digital Color Images**

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Sr.No	Country	Application Number	Filing Date	Name of the Applicant	Title of the Invention

6. PARTICULARS FOR FILING PATENT COOPERATION TREATY (PCT) NATIONAL PHASE APPLICATION:

International Application Number	International Filing Date as Allotted by the Receiving Office
PCT//	

7. PARTICULARS FOR FILING DIVISIONAL APPLICATION

Original (first) Application Number	Date of Filing of Original (first) Application

8. PARTICULARS FOR FILING PATENT OF ADDITION:

Main Application / Patent Number:	Date of Filing of Main Application

9. DECLARATIONS:

(i) Declaration by the inventor(s):

I/We, Prof.M.James Stephen, Dr.Praveen Babu Choppala, Mr.Srinivas Rao Gantenapalli, Mr.Y.Vishnu Tej, Prof. P.V.G.D. Prasad Reddy., is/are the true & first inventor(s) for this invention and declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a)Date: ----- Dated this 27th day of January, 2022

(b)Signature(s) of the inventor(s): ....

(c)Name(s):
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Dr.Praveen Babu Choppala

Mr.Srinivas Rao Gantenapalli
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Prof. P.V.G.D. Prasad Reddy

(ii) Declaration by the applicant(s) in the convention country:

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a)Date: ----- Dated this 27th day of January, 2022

(b)Signature(s) of the inventor(s): ....

(c)Name(s):
Prof.M.James Stephen
Dr.Praveen Babu Choppala
Mr.Srinivas Rao Gantenapalli
Mr.Y.Vishnu Tej
Prof. P.V.G.D. Prasad Reddy

(iii) Declaration by the Applicant(s):

- **The Complete specification relating to the invention is filed with this application.**
- **I am/ We are, in the possession of the above mentioned invention.**
- **There is no lawful ground of objection to the grant of the Patent to me/us.**

10. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION:

Sr.No	Document Description	File Name
1	Complete Specifications(Form-2)	CompletespecificationsForm2.pdf
2	Drawings	Drawings.pdf
3	Request For Early Publication(Form-9)	Form9.pdf
4	Statement of Undertaking (Form 3)	Form3.pdf
5	Declaration of Inventorship (Form 5)	Form5.pdf

I/We hereby declare that to the best of my/our knowledge, information and belief the fact and matters stated herein are correct and I/We request that a patent may be granted to me/us for the said invention.

Dated this (Final Payment Date): -------- Signature: ....

Name(s):

Prof.M.James Stephen

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To

The Controller of Patents

The Patent office at CHENNAI

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(62) Divisional to Application Number Filing Date	:NA :NA

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(57) Abstract :

The proposed invention provides a novel approach for filtering out impulse noise in digital color images. Specially in biomedical imaging, visual tracking, etc. The conventional filtering methods operate by applying a noise reduction scheme, generally the vector median filtering approach and its variants, for the center pixel of a suitably chosen window that iteratively slides along the entire image. These methods consider the window in its entirety in the filtering process. This consideration, however, comprehends the noise within the noisy pixels in the filtering process and could prove detrimental to the overall output. The method disclosed in this invention operates by clustering the pixels in the chosen window into two groups, one that corresponds to the pixel intensities that lie in the signal space and the other to those that lie in the noise space. However, the present method operates by clustering the pixels in the chosen window into two groups, one that corresponds to the pixel intensities that lie in the signal space and the other to those that lie in the noise space.

No. of Pages : 28 No. of Claims : 9

FORM 2

THE PATENTS ACT, 1970

(39 of 1970) &

THE PATENTS RULES, 2003

COMPLETE SPECIFICATION

(See section 10, rule 13)

1. TITLE OF THE INVENTION:

A SYSTEM FOR NOISE REDUCTION IN DIGITAL COLOR IMAGES

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5	Prof. P.V.G.D. Prasad Reddy	Indian	Senior Professor, Department of CS & SE, A.U. College of Engineering (A), Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code:530003	India	Andhra Pradesh

3. PREAMBLE TO THE DESCRIPTION:

COMPLETE SPECIFICATION

The following specification particularly describes the invention and the manner in which it is to be performed.

A SYSTEM FOR NOISE REDUCTION IN DIGITAL COLOR IMAGES

FIELD OF INVENTION

The present invention relates to the technical field of image processing.

Particularly, the present invention is related to a system for noise reduction in digital color images of the broader field of Image Processing of Computer Science Engineering.

More particularly, the present invention relates to a method, apparatus, and computer program for processing digital images to reduce noise by filtering out impulse noise in digital color images.

BACKGROUND OF INVENTION

Digital color imaging refers to the process of scanning the real world and representing the same visually as pixel intensities in red, green, and blue components. These digital color images may undergo some unwanted noise effects, like the salt and pepper noise, impulse noise, etc. Reducing the effect of the unwanted noise in digital color images is of critical interest in applications including biomedical imaging, visual tracking, and electron tomography. The images used in these applications often get corrupted by impulse noise during the scanning or measuring process or when transmitted from one point to another thus leading to high information loss and consequently flawed interpretation of the information contained in the images. From this standpoint, the basis of this paper is to develop novel methods for reducing noise in digital color images that will be applicable to all classes for image processing applications.

Several approaches have been proposed over the years to filter out impulse noise in color images albeit most research is limited to gray scale images. The median filtering approaches are by far the most popular image filtering ones due their robustness to noise. The general idea of these methods is to examine and correct a test pixel’s (usually the center pixel) representativeness of a selected window (a set of surrounding pixels) within the image. The simplest noise reduction filter in this category is the standard median filter that computes the pixel median for each selected window over each color component and replaces the test pixel with the median. The vector median filter (VMF) is a prominently used order reducing scheme that processes color images as a vector field. This method works by replacing the test pixel by another pixel in the window that minimizes the aggregate distance across all pixels. An alternative to using distance is the use of direction as proposed in the basic vector directional filter (BVDF). This filter rather uses the angular distance between the pixels than the vector magnitudes and minimizes the aggregate angular distance across all pixels in the window. Another approach to image filtering includes directional distance filtering (DDF) that utilizes a weighted product of VMF and BVDF. The directional VMF (DVMF) is another directional scheme that operates by performing vector median filtering across the pixels that lie within, degrees from the center test pixel and then taking the VMF for the resultant. The filters of this family, and especially the VMF and directional filters can perform quite robustly especially when the correlation between the three-color components must be preserved. The problem however in these methods is that the vector pixel is processed jointly as a multichannel. Consequently, any smoothing performed therein is accounted for in all the color channels equally. This could be problematic because outliers in one color component may influence the others thereby corrupting some good pixels.

Recent work in reducing impulsive noise in digital color images can be largely attributed to the work of Bogdan Smolka et al. Their contributions include the adaptive rank weighted switching filter (ARWSF) and the adaptive switching trimmed (AST) filters and others. These methods have shown promise and superiority in reducing the impulsive noise. Other techniques for noise reduction include extended versions of VMF like the alpha trimmed VMF, the adaptive switching filters, the peer group filters and the adaptive weighted directional difference methods. We neglect these as they are either limited to gray scale images or perform comparably to the aforementioned techniques or are not specific to filtering based on directional approach. Moreover, research into noise reduction in images is twofold: (a) detecting whether a pixel is corrupted by impulse noise which is relatively difficult in random valued impulse noise, and (b) filtering out the noise. The present invention is based on detecting the corrupted pixel using impulse noise.

Therefore, the present invention provides an isolated vector median filtering using k-means clustering for noise reduction in digital color images.

It is an object of the present invention to provide an improved method and system to address the existing challenge. Alternatively, it is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

The Impulse Noise Model:

In this section, we set the notation and describe the impulse noise model for a digital color image. Let X be the color image of $M \times N$ pixels containing MN pixels where M denotes the number of rows and N the number of columns. Then the color image X will be a set of vector pixels

$$X = \{x_{i,j}, i = 1, 2\ldots.., M, j = 1,2,\ldots\ldots, N\} \tag{1}$$

with each pixel being a joint vector containing the color intensities in the red, green and blue components as

$$x_{i,j} = (\boldsymbol{x}_{i,j,r}, x_{i,j,g}, x_{i,j,b}), i = 1,\ldots, M, j = 1,\ldots, N \tag{2}$$

Let $Z = \{z_{i,j}, i = 1,\ldots, M, j = 1,\ldots, N\}$ be the image corrupted by impulse noise. As discussed earlier, impulse noise is mainly classified as fixed valued impulse noise (a.k.a. salt and pepper noise) and random valued impulse noise. In the fixed valued impulse noise, a pixel is corrupted with probability $p \in (0,1)$. A corrupted pixel implies that one of its red, green or blue components get corrupted by railing to 0 (full black) or 255 (full white) with uniform probability across the color components. In the random valued impulse noise, the corrupted pixels take any random value between 0 to 255 instead of railing to high or low values. This model in general can be described as

$$z_{i,j} = \begin{cases} x_{i,j} & if\ q \geq p \\ (x_{i,j,r}, x_{i,j,g}, a) & if\ q < p, r < \frac{1}{3} \\ (x_{i,j,r}, a, x_{i,j,b}) & if\ q < p, \frac{1}{3} \leq r < \frac{2}{3} \\ (a, x_{i,j,g}, x_{i,j,b}) & if\ q < p, \frac{2}{3} \leq r \end{cases} \tag{3}$$

where $(r, q) \in (0,1)$ are continuous random numbers chosen uniformly and $a = 1$ or 255 is uniformly chosen for fixed valued impulse noise, $a \in (0, 255)$ is uniformly chosen within the interval for random valued impulse noise. This description indicates that p denotes the noise probability of an image and the closer the value of p to one, the higher the noise and the closer the value of p to zero, the lower the noise. The aim of noise reduction techniques is to restore the original image from the noisy image.

Conventional Noise Reduction Filters:

Here conventional impulse noise filtering methods in brief is provided which is used in the invention. The filtering process in general uses a sliding window W containing n pixels and of size √n×√n. For convenience we donate the set of pixels contained in the window as

$$W = \{ x_i, i = 1,\ldots, n\} \quad (4)$$

where the joint vector is x_i=$(x_{i,r}, x_{i,g}, x_{i,b})$. With this notation, the digital color image in (1) is now modified as

$$X = \{x_i , i = 1,\ldots, MN\} \quad (5)$$

The filtering methods operate by detecting and processing the centre pixel within the test window *W.* An example of the test window is shown in Figure 1. The most prominentof all filtering schemes is the VMF method. Here the aggregated distance of each pixel from every other pixel is computed as

$$\boldsymbol{S}_i = \sum_{j=1}^{n} d(x_\mathrm{i} - x_\mathrm{j}), i = 1, 2, \ldots, n \quad (6)$$

where $d(x_i - x_j)$ is the Minowski's distance between two joint pixels $x_i$and x_j , and reorder the aggregate as

$$\boldsymbol{S}_{\hat{i}=1,\ldots,n} \Rightarrow x_{\hat{i}=1,\ldots,n} : \boldsymbol{S}_{\hat{i}=1} \le \boldsymbol{S}_{\hat{i}=2} \le \ldots \le \boldsymbol{S}_{\hat{i}=n} \quad (7)$$

Then the centre pixel is replaced with the pixel having the minimum aggregate distance from all other pixels as

$$x_c = x_{i-1} \quad (8)$$

The BVDF, on the contrary, uses the aggregate angular distance between the pixels as

$$\theta_i = \sum_{j=1}^{n} \cos^{-1}\left(\frac{x_\mathbf{i} x_\mathbf{j}}{\|x_\mathbf{i}\|\|x_\mathbf{j}\|}\right), i = 1, 2, ..., n \tag{9}$$

and replaces the centre pixel with the pixel that minimises as described in (7) and (8). The DDF uses the weighted product of the Minowski's distance and the angular distance as

$$A_i = S_i^{\gamma} \theta_i^{(1-\gamma)}, i = 1, 2, ..., n \tag{10}$$

Where $\gamma \in (0,1)$. The DVMF filter operates by taking the VMF of the pixels lying in degrees to the centre pixel as shown in Figure 2 and then taking the VMF of the resultant. The VMFDD approach takes the sum of the distances along four different directions and then selects those pixels that lie in the angle that minimises the sum from the centre pixel and VMF is performed over those pixels. The alpha-trimming approach trims the distances by a chosen trimming factor ∝ while the AST method applies a switching condition for the trimming process.

In all these methods the focus is on reducing the noise by applying the VMF mechanism in different variants. There is little work in identifying pixels that correspond to noise and mitigating their effect in the filtering process. The peer group filter attempted this approach but was limited to gray scale images. The recently proposed ARWSF ranks combines the process of identifying good pixels (those that contribute to the signal/information) by first computing the distances of the pixels d(.) in the sliding window and then scaling the distances using a decaying function. This scaling gives high weighting to those pixels having minimum aggregate distance. Performing VMF over pixels using the scaling results in improved noise reduction as the most informative pixels are weighted highly in the filtering process. In the subsequent section, we propose the IMF-KM method which improves of the ARWSF method and fully marginalises the noise pixels for improved noise reduction.

SUMMARY OF INVENTION

The proposed invention provides a novel approach for filtering out impulse noise in digital color images. Specially in biomedical imaging, visual tracking, etc. The conventional filtering methods operate by applying a noise reduction scheme, generally the vector median filtering approach and its variants, for the center pixel of a suitably chosen window that iteratively slides along the entire image. These methods consider the window in its entirety in the filtering process. This consideration, however, comprehends the noise within the noisy pixels in the filtering process and could prove detrimental to the overall output. However, the present method operates by clustering the pixels in the chosen window into two groups, one that corresponds to the pixel intensities that lie in the signal space and the other to those that lie in the noise space. The motivating rationale for this clustering technique is to marginalize those pixels that lie in the noise space that seemingly do not contribute to the information in the image. The median filter is then applied to the pixels that contribute to the signal, in isolation of the color components, to filter out the impulse noise. Simulation results show that the proposed method outperforms conventional filtering methods in terms of noise reduction and structural similarity and thus validates the proposed approach.

Further, this present invention proposes a new filtering approach to reduce impulse noise in digital color images. The current art operates by clustering the pixels in a chosen sliding window into two groups, the first that encompasses the signal and the second that encompasses the noise. Through using the well-known k-means method with K=2 to accomplish this clustering based on the pixel intensities. The key rationale in grouping the pixels in a sliding window into signal and noise components is that the pixels that encompass the signal will be numerous and will have their intensities in close proximity while those that encompass the noise will be few and will have their intensities distant from those corresponding to the signal space. Based on the said rationale, the cluster having the maximum number of pixels will encompass the signal space. The pixels in this cluster are filtered using the median filter to determine the new value of the test (center) pixel. The median filter is applied on isolated color components to avoid the effect of the filtering process to be leveraged in the adjacent color components. This method, in essence, uses those pixels that seemingly contribute to the signal and thereby we mitigate the effect of the corrupted pixels in the filtering process. The present technique provides an improved accuracy. The simulation results show that the present proposed method outperforms the state-of-the-art impulse noise reduction filters.

The present invention sets the notation and describes the impulse noise. The present method is followed by the conventional impulse noise reductions methods and the proposed isolated Vector Median Filtering using k-means clustering (IMF-KM) filter.

The key idea of the proposed IMF-KM method is twofold, (a) to categorize the pixels in the sliding window into two groups, one that contributes to the signal and the other that contributes to the noise, and (b) to perform median filtering, in isolation of the color components, over the pixel intensities that contribute to the signal. The step (a) categorizes the pixels based on the spatial placement of their intensities using the k-means clustering algorithm. The cluster of intensities that contribute to the signal is then processed via the median filter. This process is performed in isolation over the color components to avoid the effect of smoothing or softening or smearing in one color component leveraging itself on the rest. The present invention choses this approach as it more effective in reducing impulsive noise in several images.

The invention disclosed herein is the isolated median filtering with k means clustering for noise reduction in digital color images. The method is two-fold, one to categorise the pixels in the sliding window into two groups, one that contributes to the signal and the other that contributes to the noise, and then to perform median filtering, in isolation of the color components, over the pixel intensities that contribute to the signal. The key merit of this invention is that using only the useful pixels for median filtering in isolation of the color components will result in smoothing that stays local and does not affect the other color components and hence leads to improved accuracy in image reconstruction. This invention demonstrated the superiority of the proposed method using real images and several statistical measures.

BRIEF DESCRIPTION OF SYSTEM

The Accompanying Drawings are included to provide further understanding of the invention disclosed here, and are incorporated in and constitute a part this specification. The drawing illustrates exemplary embodiments of the present disclosure and, together with the description, serves to explain the principles of the present disclosure. The Drawings are for illustration only, which thus not a limitation of the present disclosure.

Referring to Figure 1, illustrates a 3× 3 test window with $n = 3^2 = 9$ with centre pixel as test pixel, in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 2, illustrates a pictorial representation of DVMF, in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 3, illustrates the original test image-1, in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 4, illustrates Noise Reduction by various filters: Left to right: (a) Noisy image, (b) Median filter, (c) VMF, (d) BVDF, (e) DDF, (f) DVMF, (g) VMFDD, (h) ARWSF, (i) Alpha trim, (j) AST, (k) IMF-KM. Top to bottom: Noise probability p = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95., in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 5, illustrates the RMSE versus the Noise Probability for test image-1, in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 6, illustrates the PSNR versus the Noise Probability for test image-1, in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 7, illustrates the SSIM versus the Noise Probability for test image-1, in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 8, illustrates various test images (a) Test Image-2 (b) Test Image-3 (c) Test Image-4, in accordance with an exemplary embodiment of the disclosure.

Referring to Figure 9, illustrates Performance statistics for Test Images-2, Test Image-3 and Test Image-4 **(a)** The RMSE versus the Noise Probability **(b)** The PSNR versus the Noise Probability **(c)** The SSIM versus the Noise Probability, in accordance with an exemplary embodiment of the disclosure.

DETAIL DESCRIPTION OF THE PRESENT INVENTION

Description of the Invention for a thorough understanding of the present invention, reference is made to the following detailed description in connection with the abovementioned drawings. Although the present invention is described with reference to exemplary embodiments, the present invention is not intended to be limited to the specific forms set forth herein. It is understood that various omissions and substitutions of equivalents are contemplated as circumstances may suggest or render expedient, but these are intended to cover the application or implementation without departing from the spirit or scope of the present invention.

Further, it will nevertheless be understood that no limitation in the scope of the invention is thereby intended, such alterations and further modifications in the figures and such further applications of the principles of the invention as illustrated herein being contemplated as would normally occur to one skilled in the art to which the invention relates.

Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. Further, reference herein to “one embodiment” or “an embodiment” means that a particular feature, characteristic, or function described in connection with the embodiment is included in at least one embodiment of the invention.

Furthermore, the appearances of such phrase at various places herein are not necessarily all referring to the same embodiment. The terms “a” and “an” herein do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items.

The present invention relates to a method, apparatus, and computer program for processing digital images to reduce noise. More particularly, filtering out impulse noise in digital color images.

The present invention provides an isolated vector median filtering using k-means clustering for noise reduction in digital color images.

The present invention sets the notation and describes the impulse noise. The present method is followed by the conventional impulse noise reductions methods and the proposed isolated Vector Median Filtering using k-means clustering (IMF-KM) filter.

The proposed invention provides a novel approach for filtering out impulse noise in digital color images. Specially in biomedical imaging, visual tracking, etc. The conventional filtering methods operate by applying a noise reduction scheme, generally the vector median filtering approach and its variants, for the center pixel of a suitably chosen window that iteratively slides along the entire image. These methods consider the window in its entirety in the filtering process. This consideration, however, comprehends the noise within the noisy pixels in the filtering process and could prove detrimental to the overall output. However, the present method operates by clustering the pixels in the chosen window into two groups, one that corresponds to the pixel intensities that lie in the signal space and the other to those that lie in the noise space. The motivating rationale for this clustering technique is to marginalize those pixels that lie in the noise space that seemingly do not contribute to the information in the image. The median filter is then applied to the pixels that contribute to the signal, in isolation of the color components, to filter out the impulse noise. Simulation results show that the proposed method outperforms conventional filtering methods in terms of noise reduction and structural similarity and thus validates the proposed approach.

Further, this present invention proposes a new filtering approach to reduce impulse noise in digital color images. The current art operates by clustering the pixels in a chosen sliding window into two groups, the first that encompasses the signal and the second that encompasses the noise. Through using the well-known k-means method with K=2 to accomplish this clustering based on the pixel intensities. The key rationale in grouping the pixels in a sliding window into signal and noise components is that the pixels that encompass the signal will be numerous and will have their intensities in close proximity while those that encompass the noise will be few and will have their intensities distant from those corresponding to the signal space. Based on the said rationale, the cluster having the maximum number of pixels will encompass the signal space. The pixels in this cluster are filtered using the median filter to determine the new value of the test (center) pixel. The median filter is applied on isolated color components to avoid the effect of the filtering process to be leveraged in the adjacent color components. This method, in essence, uses those pixels that seemingly contribute to the signal and thereby we mitigate the effect of the corrupted pixels in the filtering process. The present technique provides an improved accuracy. The simulation results show that the present proposed method outperforms the state-of-the-art impulse noise reduction filters.

The present invention sets the notation and describes the impulse noise. The present method is followed by the conventional impulse noise reductions methods and the proposed isolated Vector Median Filtering using k-means clustering (IMF-KM) filter.

The key idea of the proposed IMF-KM method is twofold, (a) to categorize the pixels in the sliding window into two groups, one that contributes to the signal and the other that contributes to the noise, and (b) to perform median filtering, in isolation of the color components, over the pixel intensities that contribute to the signal. The step (a) categorizes the pixels based on the spatial placement of their intensities using the k-means clustering algorithm. The cluster of intensities that contribute to the signal is then processed via the median filter. This process is performed in isolation over the color components to avoid the effect of smoothing or softening or smearing in one color component leveraging itself on the rest. The present invention choses this approach as it more effective in reducing impulsive noise in several images.

Consider a sliding window $W = \{x_i , i = 1, \cdots, n\}$ containing n pixels. From W, we obtain the isolated color sliding windows as

$$W_r = \{x_{r,i}, i = 1, \cdots, n\} \quad (11)$$

$$W_g = \{x_{g,i}, i = 1, \cdots, n\} \quad (12)$$

$$W_b = \{x_{b,i}, i = 1, \cdots, n\} \quad (13)$$

The methodology proposed in the sequel corresponds to the red color component. The reader is notified that the methodology proposed in the sequel corresponds to the red color component and should be extended to the green and blue components as is in isolation of the color components. Consider the sliding window corresponding to the red component $W_r = \{x_{r,i}, i = 1, \cdots, n\}$. This window contains the red component pixel intensities. These intensity values are then clustered into two groups using the unsupervised learning method, the k-means method with K = 2. The k-means method over the sliding window results in a responsibility vector

$$R_r = \{j_i , j_i \in (1, 2), i = 1, \cdots, n\} \quad (14)$$

$$R_r = \{j_{i=1,\cdots,n} = 1\} \cup \{j_{i=1,\cdots,n} = 2\} \quad (15)$$

$$R_r = R_r[1] \cup R_r[2] \quad (17)$$

such that the ith responsibility variable j_i takes any of the two values, 1 or 2, indicating the cluster number to which the ith pixel intensity $x_{r,i}$ belongs. The set $R_r[1]$ contains the indices This lets us categorise the n pixels into two clusters as

$$C_r[1] = \{x_{j_i,r} : j_i = 1\}, i = 1, \cdots, n \quad (18)$$

$$C_r[2] = \{x_{j_i,r} : j_i = 2\}, i = 1, \cdots, n \quad (19)$$

We then take the cluster containing the maximum pixel values according to

$$\eta_r = C_r[j] \ s.t. |C_r[j]| > |C_r[i \in (1, 2), i \neq j]| \quad (20)$$

where |.| of a set denotes its cardinality. Essentially, this method clusters the pixel intensities in the sliding window into two groups, the first — the dominant set η_r assumingly lying in the signal space, and the second assumingly lying in the noise space. We assume since the dominant set has more pixel intensities spaced close to one another, they contribute to the signal part of the image and the other set contributes to the noise. We can then perform median filtering over the pixel intensities in the dominant set and replace the red component of the center test pixel as

$$x_{c,r} = Median(\eta_r) \tag{21}$$

The process is repeated over green and blue color components in isolation and we obtain the final test pixel as

$$x_c = (x_{c,r}, x_{c,g}, x_{c,b}) \tag{22}$$

The k-means algorithm employed to cluster the pixel intensities in the red color component and to obtain the responsibility vector R_r in (4) is outlined in Algorithm 1. The proposed

Algorithm 1: The k-means algorithm

$R_r = K-MEANS\left[\{x_{i,r}, i = 1, \cdots, n\}, K\right]$

Initialise centroids $c_k = 1, \cdots, K$ at random.

while Flag Up **do**

Compute distance $D(i, k) = d(x_{i,r} - c_k), i = 1, \cdots, n, k = 1, \cdots, K$

where d(.) is any distance measure.

Compute responsibility vector $R_r = \{j_i = k : arg\ min_k D(i, k), i = 1, \cdots, n\}$.

That is, the ith sample will belong to the j_i th cluster that minimises its distance over the centroids.

Compute new centroids

$c_k = \sum x_{j_i = k, r} / \left|\{j_i = k, i = 1, \cdots, n\}\right|, k = 1, \cdots, K$

if $c_k, k = 1, \ldots\ldots, k$ values unchanged **then** Flag Down

end if

end while

IMF-KM method for the red color component is outlined in Algorithm 2.

Algorithm 2: The proposed **IMF-KM** algorithm

$x_{c,r} = IMF - KM\left[W_r = \{x_{i,r},\ i = 1, \cdots, n\}\right]$

Cluster the pixel intensities using k-means algorithm and obtain responsibility vector $R_r = K - MEANS\left[\left\{x_{i,r},\ i = 1, \cdots, n\right\},\ K = 2\right]$

Categorise the n pixels into two clusters

$C_r[j] = \left\{x_{j_{i,r}} : j_i = 1\right\},\ i = 1, \cdots, n,\ j = 1, 2$

Determine the dominant cluster η_r according to (9).

The center test pixel is $x_{c,r} = Median(\eta_r)$

Simulation and Comparison:

In the present invention disclosed herein, we compare the proposed IMF-KM with state-of-the-art vector median filters using four test statistics.

The first is the root mean square error (RMSE) defined as

$$RMSE(X,Y) = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left\|X_{i,j} - Y_{i,j}\right\|^2} \quad (22)$$

where *X, Y* respectively are the original and filtered images. A small value of the RMSE indicates that the error between the filtered image and the original is small and hence we desire small RMSE values. The second measure is the peak signal to-noise ratio (PSNR) defined as

$$PSNR(X,Y) = 10\log_{10}\left(\frac{Max(X)^2}{MSE(X,Y)}\right) \quad (23)$$

where *MSE* (*X*, *Y*) is the mean square error of the filtered image. A high PSNR is desirable because it indicates good signal recovery from the noise. The third measure is the structural similarity index (SSIM) defined as

$$SSIM(X,Y) = \frac{(2\mu_x + \mu_y + c_1)(2C_{X,Y} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad (24)$$

where the image means are

$$\mu_x = \frac{1}{N}\sum_{i=1}^{N} X_i \qquad (25)$$

$$\mu_y = \frac{1}{N}\sum_{i=1}^{N} Y_i \qquad (26)$$

and $\sigma_2\ (.)$ denotes the variance and $C\ (.,.)$ denotes the covariance between the original and filtered images. The SSIM value denotes the similarity between two images, the original and the filtered in our case, by incorporating perceptual features including luminance and contrast. A high value of SSIM indicates accurate reconstruction of the original image. We first demonstrate the superiority of the proposed IMF-KM method over state-of-the art filtering methods.

Referring to Figure 3, illustrates the original test image-1, in accordance with an exemplary embodiment of the disclosure. In this figure 3, invention display the test case image-1 used for this purpose.

Referring to Figure 4, illustrates Noise Reduction by various filters: Left to right: (a) Noisy image, (b) Median filter, (c) VMF, (d) BVDF, (e) DDF, (f) DVMF, (g) VMFDD, (h) ARWSF, (i) Alpha trim, (j) AST, (k) IMF-KM. Top to bottom: Noise probability p = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95., in accordance with an exemplary embodiment of the disclosure. For the test case image-1, figure 4 shows the noisy image and the filtered images at varying noise probabilities and it can be visually observed that the last column corresponding to the proposed IMF-KM method outperforms the other methods.

Referring to Figure 5, Figure 6 and Figure 7 illustrates the RMSE versus the Noise Probability, PSNR versus the Noise Probability and SSIM versus the Noise Probability for test image-1, in accordance with an exemplary embodiment of the disclosure. It can be seen that our IMF-KM method shows improved accuracy (i.e., low RMSE) than that of the joint vector approaches and also the IVMDF approach and the efficiency will increase with increase in noise probability.

The present invention further defines the IMF-KM method over state-of-the art filtering methods. For example, the noisy image and the filtered images at varying noise probabilities and it can be visually observed that the last column corresponding to the proposed IMF-KM method outperforms the other methods.

Furthermore, the IMF-KM method shows improved accuracy (i.e., low RMSE) than that of the joint vector approaches and the IVMDF approach and the efficiency will increase with increase in noise probability. In terms of the RMSE, the method exhibits only 0.7 times the efficiency of the VMF at = 0.2, However its performance improves from = 0.4 and is twice better at = 0.6 and nearly 2.34 times better at = 0.95. This tremendous improvement could be attributed to the best use of pixels that contribute to the information in the sliding window. The superiority can also be explained in terms of the structural similarity. The proposed IMF-KM method shows only 0.7% improvement over the VMF method at = 0.2 but this becomes increasingly efficient to about 15% at = 0.95. This shows that the isolated median filtering of only the useful pixels, i.e., those pixels that lie in the signal space and supposedly contain useful information, will result in improved impulse noise reduction.

Referring to Figure 8, illustrates various test images (a) Test Image-2 (b) Test Image-3 (c) Test Image-4, in accordance with an exemplary embodiment of the disclosure.For these test cases, the results show the noisy image and the filtered images at varying noise probabilities and it can be visually observed that the proposed IMF-KM method outperforms the other methods. From all the test cases, it can be observed that the proposed IMF-KM method outperforms all other methods and shows similar performance across all test cases and across all values of.

Referring to Figure 9, illustrates Performance statistics for Test Images-2, Test Image-3 and Test Image-4 **(a)** The RMSE versus the Noise Probability **(b)** The PSNR versus the Noise Probability **(c)** The SSIM versus the Noise Probability, in accordance with an exemplary embodiment of the disclosure. The RMSE, PSNR and SSIM performance statistics indicate that of all the tested methods the VMF and the DVMF methods compare favorably to the proposed IMF-KM method despite the latter showing tremendous superiority of the former. Table 1 shows the ratio of the RMSE of the VMF and the DVMF methods to the proposed IMF-KM method for p from 0.5 to 0.95. Since we desire low RMSE values, the expected ratio should be greater than one. It can be observed that indeed for all the four test images, the ratio is more than 1.5 indicating a 50% improvement by the proposed method.

Table 1: The ratio of the RMSE of the VMF and DVMF methods to the IMF-KM method

P	Test Image 1		Test Image 2		Test Image 3		Test Image 4	
0.5	1.5817	1.5882	1.0115	1.032	0.9438	0.9379	1.8422	1.783
0.6	1.9165	1.9346	1.1171	1.1392	0.9903	0.9752	2.0031	1.8638
0.7	2.0827	2.0897	1.2398	1.2607	1.0681	1.0442	2.0673	1.9223
0.8	2.1938	2.1866	1.3588	1.3931	1.1503	1.1256	2.0445	1.9179
0.9	2.3415	2.3283	1.4709	1.5109	1.2173	1.1866	1.9854	1.8807
0.95	2.3369	2.3203	1.5103	1.5442	1.2435	1.2146	1.938	1.8431

Tables 2 and 3 show the ratio of the PSNR of the VMF and the DVMF methods to the proposed IMF-KM method for p from 0.5 to 0.95. Since we desire higher PSNR and SSIM values, the expected ratio should be less than one. It can be observed that indeed for all the four test images, the ratio is less than one.

Table 2: The ratio of the PSNR of the VMF and DVMF methods to the IMF-KM method

P	Test Image 1		Test Image 2		Test Image 3		Test Image 4	
0.5	0.8998	0.8989	0.9963	0.9897	1.0234	1.0259	0.8323	0.8407
0.6	0.8495	0.8475	0.9631	0.9566	1.004	1.0103	0.7902	0.8119
0.7	0.8186	0.8178	0.9266	0.9208	0.9722	0.9818	0.7602	0.7842
0.8	0.7921	0.7931	0.8923	0.8834	0.9399	0.9493	0.7399	0.7632
0.9	0.7618	0.7634	0.8615	0.8516	0.9133	0.9246	0.7278	0.7493
0.95	0.7542	0.7563	0.8484	0.8399	0.9023	0.9128	0.7257	0.7465

Table 3: The ratio of the SSIM of the VMF and DVMF methods to the IMF-KM method

P	Test Image 1		Test Image 2		Test Image 3		Test Image 4	
0.5	0.9801	0.982	0.9442	0.9478	0.9277	0.9337	0.9849	0.9869
0.6	0.9688	0.9719	0.9292	0.9338	0.9137	0.9228	0.9655	0.9712
0.7	0.9522	0.958	0.9057	0.9114	0.8829	0.8967	0.9368	0.9465
0.8	0.9266	0.9369	0.8782	0.8849	0.85	0.8651	0.8976	0.9111
0.9	0.8919	0.9075	0.8508	0.8598	0.8215	0.84	0.8564	0.8717
0.95	0.8711	0.89	0.8322	0.8436	0.8039	0.8202	0.8378	0.8528

These results, in summary, show that the proposed idea of clustering pixels within a test window to identify those that contain information and then filtering those pixels can result in improved reduction of impulse noise in digital color images.

This invention proposed the isolated median filtering with k means clustering for noise reduction in digital color images. The method is two-fold, one to categorize the pixels in the sliding window into two groups, one that contributes to the signal and the other that contributes to the noise, and then to perform median filtering, in isolation of the color components, over the pixel intensities that contribute to the signal. The key merit of this proposal is that using only the useful pixels for median filtering in isolation of the color components will result in smoothing that stays local and does not affect the other color components and hence leads to improved accuracy in image reconstruction. We have demonstrated the superiority of the proposed method using real images and several statistical measures.

It is accordingly an object of the present invention to provide a novel approach for filtering out impulse noise in digital color images. Unlike, the conventional filtering methods operate by applying a noise reduction scheme, generally the vector median filtering approach and its variants, for the center pixel of a suitably chosen window that iteratively slides along the entire image. These methods consider the window in its entirety in the filtering process. Especially in biomedical imaging, visual tracking, etc. Therefore, the present invention provides an isolated vector median filtering using k-means clustering for noise reduction in digital color images.

What has been described above includes examples of the subject invention. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the subject invention, but one of ordinary skill in the art may recognize that many further combinations and permutations of the subject invention are possible. Accordingly, the subject invention is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

The foregoing descriptions of specific exemplary embodiments of the present invention have been presented for purposes of illustration and description only. They are not intended to be exhaustive or to limit the invention to the precise forms and sequence of steps disclosed, and obviously many modifications and variations are possible considering the above teachings.

The exemplary embodiments were chosen and described in order to explain certain principles of the invention and their practical application, thereby enabling others skilled in the art to make and utilize various exemplary embodiments of the present invention, as well as various alternatives and modifications thereof.

Meka James Stephen Digitally signed by Meka James Stephen Date: 2022.01.27 12:48:07 +05'30'

CLAIMS

We claim:

1. A system for noise reduction in digital color images, comprising: an isolated vector median filtering using k-means clustering for noise reduction in digital color images; and impulse noise reductions methods and the proposed isolated Vector Median Filtering using k-means clustering (IMF-KM) filter.

2. The system as claimed in claim 1, wherein the filtering out impulse noise in digital color images. Specially in biomedical imaging, visual tracking, etc. The conventional filtering methods operate by applying a noise reduction scheme, generally the vector median filtering approach and its variants, for the center pixel of a suitably chosen window that iteratively slides along the entire image.

3. The system as claimed in claim 1, wherein the present method operates by clustering the pixels in the chosen window into two groups, one that corresponds to the pixel intensities that lie in the signal space and the other to those that lie in the noise space.

4. The system as claimed in claim 1, wherein the motivating rationale for this clustering technique is to marginalize those pixels that lie in the noise space that seemingly do not contribute to the information in the image.

5. The system as claimed in claim 1, wherein the median filter is then applied to the pixels that contribute to the signal, in isolation of the color components, to filter out the impulse noise.

6. The system as claimed in claim 1, wherein IMF-KM method is twofold, (a) to categorize the pixels in the sliding window into two groups, one that contributes to the signal and the other that contributes to the noise, and (b) to perform median filtering, in isolation of the color components, over the pixel intensities that contribute to the signal.

7. The system as claimed in claim 1, wherein the cluster of intensities that contributes to the signal is then processed via the median filter.

8. The system as claimed in claim 1, wherein the pixels in this cluster are filtered using the median filter to determine the new value of the test (center) pixel.

9. The system as claimed in claim 1, wherein the median filter is applied on isolated color components to avoid the effect of the filtering process to be leveraged in the adjacent color components.

Dated this 27th day of January, 2022

Meka James Stephen Digitally signed by Meka James Stephen
Date: 2022.01.27 12:47:49 +05'30'

A SYSTEM FOR NOISE REDUCTION IN DIGITAL COLOR IMAGES

ABSTRACT

The proposed invention provides a novel approach for filtering out impulse noise in digital color images. Specially in biomedical imaging, visual tracking, etc. The conventional filtering methods operate by applying a noise reduction scheme, generally the vector median filtering approach and its variants, for the center pixel of a suitably chosen window that iteratively slides along the entire image. These methods consider the window in its entirety in the filtering process. This consideration, however, comprehends the noise within the noisy pixels in the filtering process and could prove detrimental to the overall output. The method disclosed in this invention operates by clustering the pixels in the chosen window into two groups, one that corresponds to the pixel intensities that lie in the signal space and the other to those that lie in the noise space. However, the present method operates by clustering the pixels in the chosen window into two groups, one that corresponds to the pixel intensities that lie in the signal space and the other to those that lie in the noise space.

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Dated this 27th day of January, 2022

Meka James Stephen Digitally signed by Meka James Stephen
Date: 2022.01.27 12:47:15 +05'30'

DRAWINGS

Total No of Sheets: 05

Sheet No.1

Applicants: Prof.M.James Stephen, Dr.Praveen Babu Choppala, Mr.Srinivas Rao Gantenapalli, Mr.Y.Vishnu Tej, Prof. P.V.G.D. Prasad Reddy.

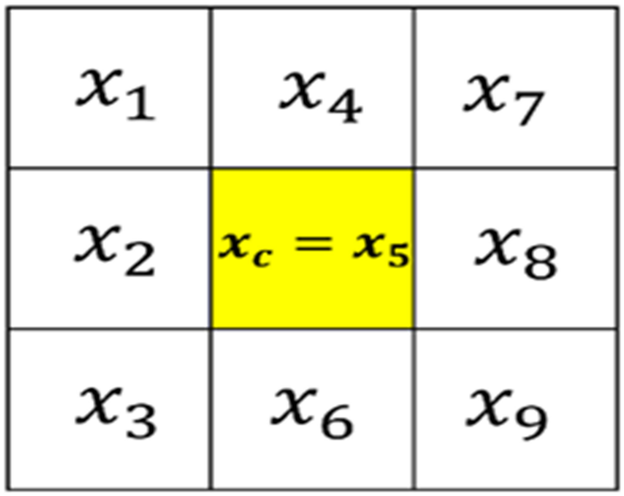

FIGURE 1: A 3× 3 test window with $n = 3^2 = 9$ with centre pixel as test pixel.

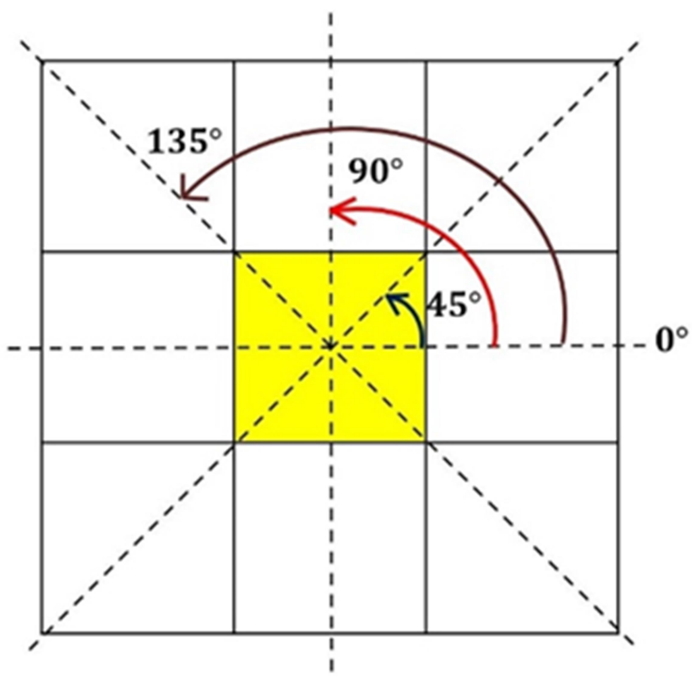

FIGURE 2: A pictorial representation of DVMF.

FIGURE 3: The original test image-1.

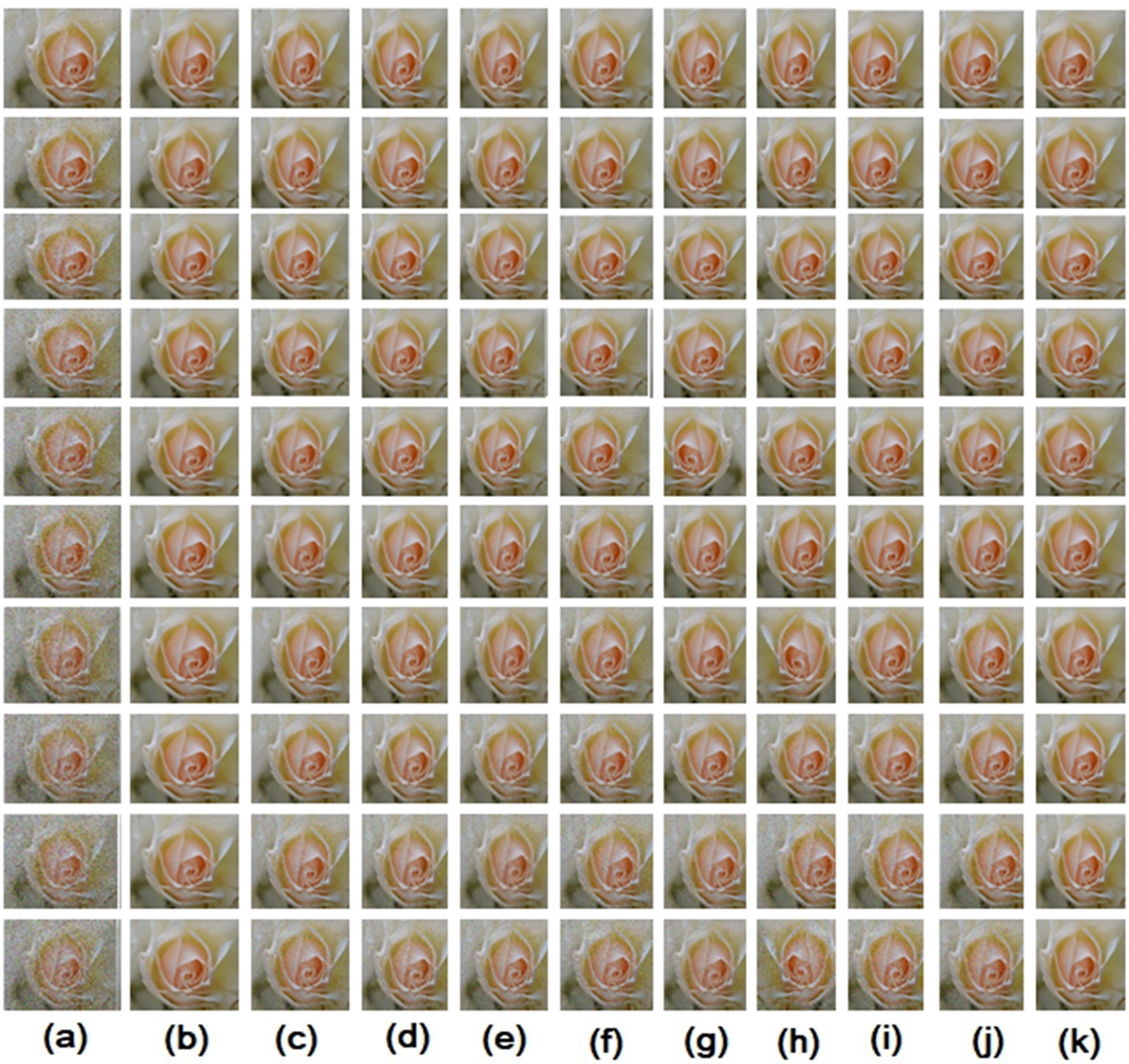

FIGURE 4: Noise Reduction by various filters: Left to right: (a) Noisy image, (b) Median filter, (c) VMF, (d) BVDF, (e) DDF, (f) DVMF, (g) VMFDD, (h) ARWSF, (i) Alpha trim, (j) AST, (k) IMF-KM. Top to bottom: Noise probability p = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95.

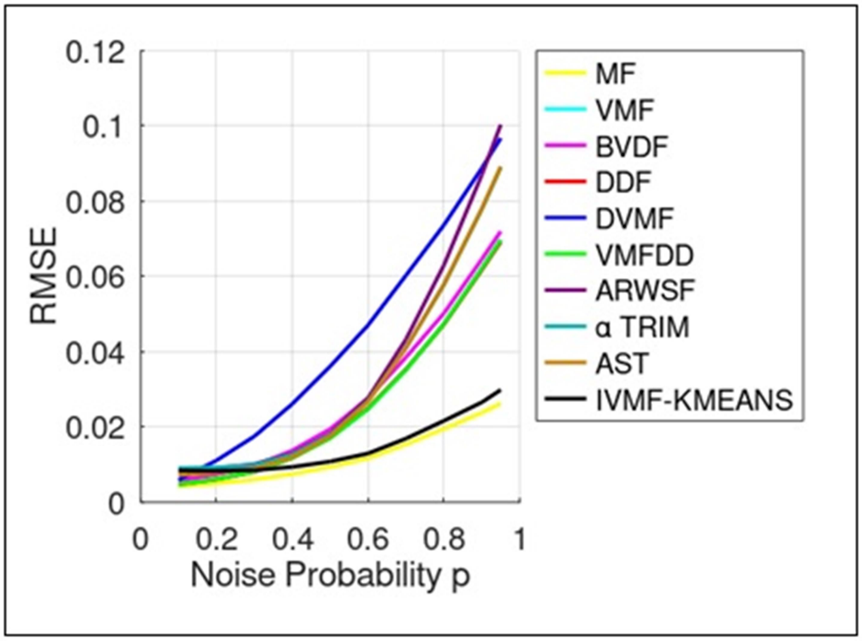

FIGURE 5: The RMSE versus the Noise Probability for test image-1.

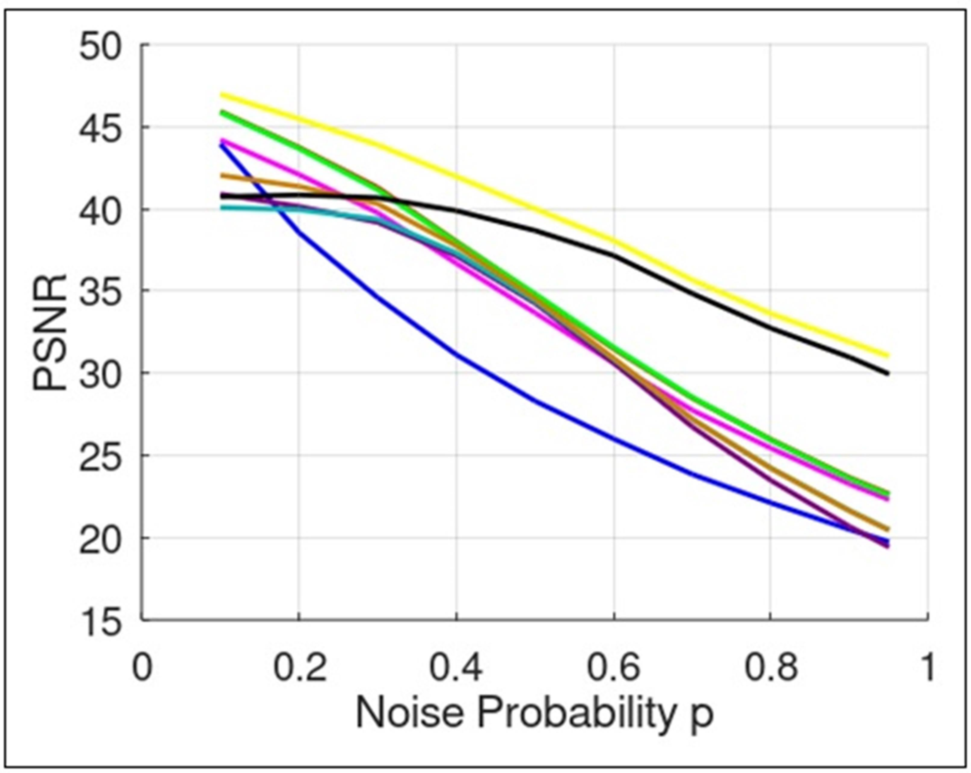

FIGURE 6: The PSNR versus the Noise Probability for test image-1.

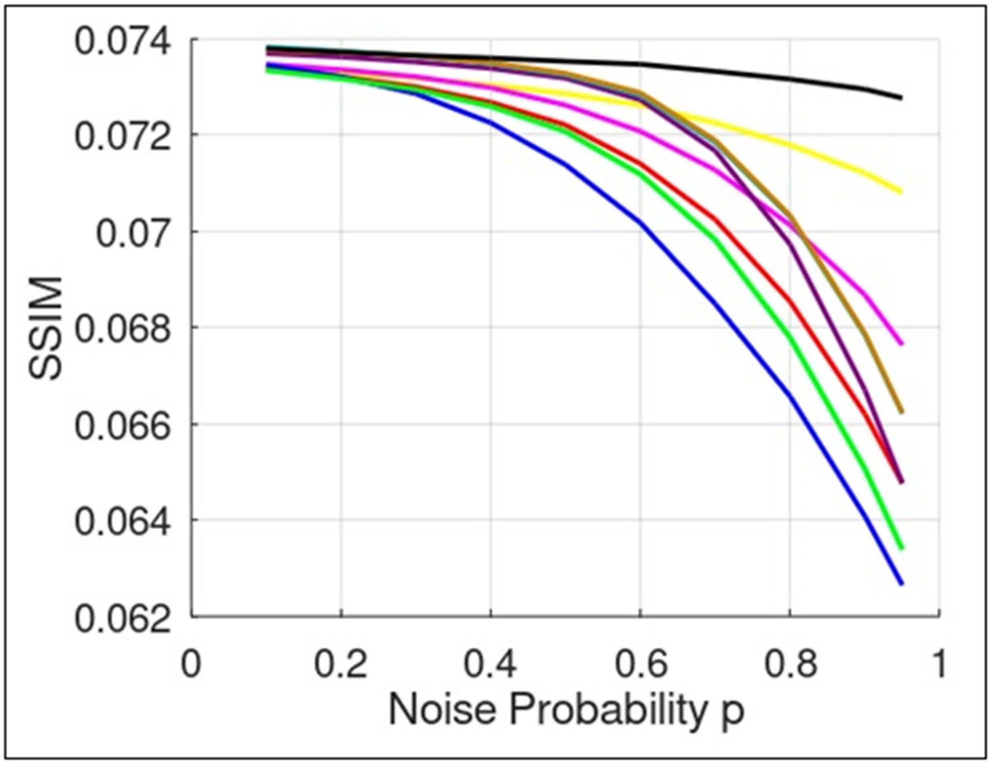

FIGURE 7: The SSIM versus the Noise Probability for test image-1.

FIGURE 8: Various test images **(a)** Test Image-2 **(b)** Test Image-3 **(c)** Test Image-4

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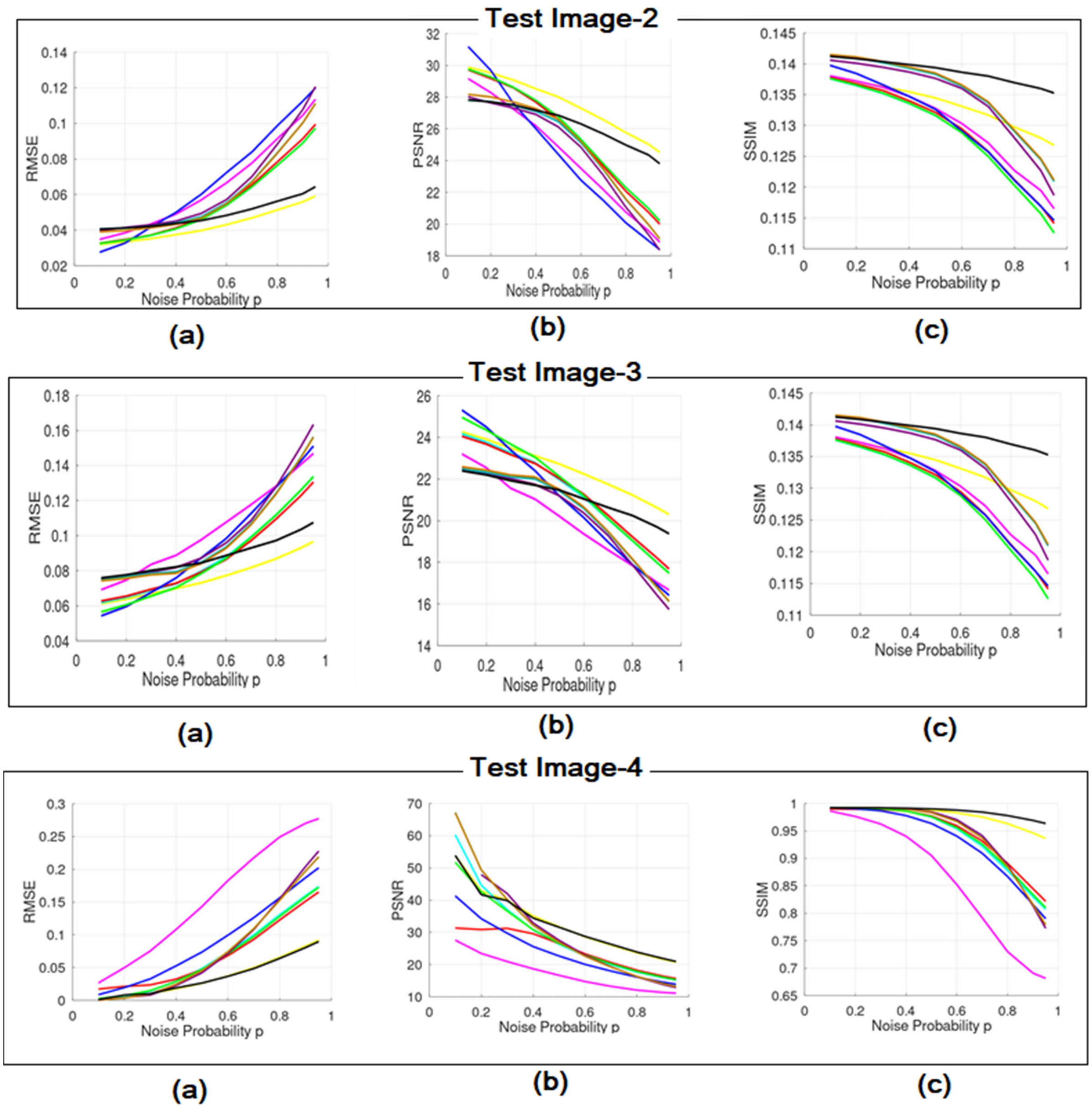

FIGURE 9: Performance statistics for Test Images-2, Test Image-3 and Test Image-4 **(a)** The RMSE versus the Noise Probability **(b)** The PSNR versus the Noise Probability **(c)** The SSIM versus the Noise Probability

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FORM 9

THE PATENT ACT, 1970
(39 of 1970)
&
THE PATENTS RULES, 2003

REQUEST FOR PUBLICATION

[See section 11A (2); rule 24A]

I/We **Prof.M.James Stephen, Dr.Praveen Babu Choppala, Mr.Srinivas Rao Gantenapalli, Mr.Y.Vishnu Tej, Prof. P.V.G.D. Prasad Reddy.,** hereby request for early publication of my/our application for patent, titled "**A System for Noise Reduction in Digital Color Images**" dated 27-01-2022, under section 11A(2) of the act.

Dated this 27th day of January, 2022 **13:00:00** under section 11A (2) of the Act.

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~~**2. To be signed by the applicant or authorized registered patent**~~

Dated this 27th day of January, 2022

3. Name of Applicant(s)/ Inventor(s) Signature(s):

Name of the natural person who has signed.	Signature:-
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Dr.Praveen Babu Choppala	
Mr.Srinivas Rao Gantenapalli	
Mr.Y.Vishnu Tej	
Prof. P.V.G.D. Prasad Reddy	

To

The Controller of Patents

The Patent office at CHENNAI

FORM 3

THE PATENTS ACT, 1970
(39 of 1970)
and
THE PATENTS RULES, 2003

STATEMENT AND UNDERTAKING
UNDER SECTION 8

(See section 8; Rule 12)

1. Name of Applicant(s):

Prof.M.James Stephen, Dr.Praveen Babu Choppala, Mr.Srinivas Rao Gantenapalli, Mr.Y.Vishnu Tej, Prof. P.V.G.D. Prasad Reddy

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I/We, Prof.M.James Stephen, Dr.Praveen Babu Choppala, Mr.Srinivas Rao Gantenapalli, Mr.Y.Vishnu Tej, Prof.P.V.G.D. Prasad Reddy., is/are the true & first inventor(s) for this invention and declare that the applicant(s) herein is/are my/our assignee or legal representative.

(i) that I/We have not made any application for the same/substantially the same invention outside India.

OR

~~(ii) that I/We who have made this application No…….dated …..……………..alone/jointly with………………………., made for the same/substantially same invention, application(s) for patent in the other countries, the particulars of which are given below:~~

Name of the country	Date of application	Application No.	Status of the application	Date of publication	Date of grant

~~**3.Name and address of the assignee**~~	(iii)that the rights in the application(s) has/have been assigned to……………………………………………... that I/We undertake that upto the date of grant of the patent by the Controller, I/We would keep him informed in writing the details regarding corresponding applications for patents filed outside India within six months from the date of filing of such application. Dated this: 27th Day of January, 2022
	Signature:…………
4. To be signed by the applicant or ~~**his authorized registered patent agent.**~~	Prof.M.James Stephen Dr.Praveen Babu Choppala Mr.Srinivas Rao Gantenapalli Mr.Y.Vishnu Tej Prof. P.V.G.D. Prasad Reddy

5. Name of the natural person who has Signed.	Prof.M.James Stephen Dr.Praveen Babu Choppala Mr.Srinivas Rao Gantenapalli Mr.Y.Vishnu Tej Prof. P.V.G.D. Prasad Reddy

To

The Controller of Patents

The Patent office at CHENNAI

FORM 5

THE PATENT ACT, 1970

(39 OF 1970) &
The Patent Rules, 2003

DECLARATION AS TO INVENTORSHIP

[See sections 10(6) and Rule 13(6)]

1. NAME OF APPLICANT(S):

Sr.No	Name	Nationality	Address	Country	State
1	Prof.M.James Stephen	Indian	Professor, Department of CSE, Wellfare Institute of Science Technology and Management (WISTM), Visakhapatnam, Andhra Pradesh, India. Pin Code:530007	India	Andhra Pradesh
2	Dr.Praveen Babu Choppala	Indian	Department of ECE, Wellfare Institute of Science Technology and Management (WISTM), Visakhapatnam, Andhra Pradesh, India. Pin Code:530007	India	Andhra Pradesh
3	Mr.Srinivas Rao Gantenapalli	Indian	Department of ECE, A.U. College of Engineering (A), Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code:530003	India	Andhra Pradesh
4	Mr.Y.Vishnu Tej	Indian	Research Scholar, Department of CS & SE, A.U. College of Engineering (A), Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code:530003	India	Andhra Pradesh
5	Prof. P.V.G.D. Prasad Reddy	Indian	Senior Professor, Department of CS & SE, A.U. College of Engineering (A), Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code:530003	India	Andhra Pradesh

I/We Prof.M.James Stephen, Dr.Praveen Babu Choppala, Mr.Srinivas Rao Gantenapalli, Mr.Y.Vishnu Tej, Prof. P.V.G.D. Prasad Reddy., hereby declare that the true and first inventor(s) of the invention disclosed in the complete specification filed in pursuance of my/our application numbered…….dated is/are:

2. INVENTOR(s):

Sr.No	Name	Nationality	Address	Country	State
1	Prof.M.James Stephen	Indian	Professor, Department of CSE, Wellfare Institute of Science Technology and Management (WISTM), Visakhapatnam, Andhra Pradesh, India. Pin Code:530007	India	Andhra Pradesh
2	Dr.Praveen Babu Choppala	Indian	Department of ECE, Wellfare Institute of Science Technology and Management (WISTM), Visakhapatnam, Andhra Pradesh, India. Pin Code:530007	India	Andhra Pradesh
3	Mr.Srinivas Rao Gantenapalli	Indian	Department of ECE, A.U. College of Engineering (A), Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code:530003	India	Andhra Pradesh
4	Mr.Y.Vishnu Tej	Indian	Research Scholar, Department of CS & SE, A.U. College of Engineering (A), Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code:530003	India	Andhra Pradesh
5	Prof. P.V.G.D. Prasad Reddy	Indian	Senior Professor, Department of CS & SE, A.U. College of Engineering (A), Andhra University, Visakhapatnam, Andhra Pradesh, India. Pin Code:530003	India	Andhra Pradesh

Dated this…27th day of January, 2022

Name of the Signatory	Signature:-
Prof.M.James Stephen	
Dr.Praveen Babu Choppala	
Mr.Srinivas Rao Gantenapalli	
Mr.Y.Vishnu Tej	
Prof. P.V.G.D. Prasad Reddy	

3. DECLARATION TO BE GIVEN WHEN THE APPLICATION IN INDIA IS FILED BY THE APPLICANT (S) IN THE CONVENTION COUNTRY:-

~~We the applicant(s) in the convention country hereby declare that our right to apply for a patent in India is by way of assignment from the true and first inventor(s).~~

~~Dated this ……day of 2020~~

~~Signature:-~~

~~Name of Signatory:-~~

4. STATEMENT ~~(to be signed by the additional inventor(s) not mentioned in the application form)~~

~~I/we assent to invention referred to in the above declaration, being included in the complete specification filed in pursuance of the stated application.~~

~~Dated this ……day of 2020~~

~~Signature of the additional inventor (s)~~

~~Name :~~

To

The Controller of Patents

The Patent office at CHENNAI