Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 7, July 2021: 3053- 3067

# An Extended Review On Impulse Noise Reduction For Corrupted Images

**V.Juliet Rani**
Research Scholar,
Manonmaniam Sundaranar University,
Tirunelveli,India.
vjulietrani@gmail.com

**Dr. K.K.Thanammal**
Associate Professor,
Dept. of Comp. Science and Applications
S.T. Hindu College, Nagercoil.
thanaravindran@gmail.com

**ABSTRACT**

Image denoising is the core preprocessing work for digital images. The denoising process enhances the images from the corrupted status to the noise-free status. Many methods have been published in the literature to remove the salt and pepper noise in various image types. This survey paper makes an analysis on noise removal by considering the key-characteristics of the denoising field. This extended survey studies around 45 papers to impart the knowledge of denoising techniques for the young researches. The comparison part is built-up via the fields such as algorithm-name, merit, demerit, MSE and input image-type. This survey assesses the working methodology of each paper with brief description, and it also handles about the target of each paper. This survey lights on the path of the fresh-researchers in the image-denoising field, to decide their target method with better adaptability to their research, because image denoising is the primary task for majority of image processing tasks.

Keywords: Image-denoising, impulse noise, salt and pepper noise, image enhancement.

## I INTRODUCTION

Normally, noise is presented in digital images during image acquisition, coding, transmission, and processing steps. It is very difficult to remove noise from the digital images without the prior knowledge of filtering techniques. Digital images can be classified as binary images, grayscale images and color images. Image noise means the random variation of brightness or color information in the captured images. It is the degradation in image signal caused by external sources. The various types of noise are: Gaussian noise, Impulse (Salt-and-pepper) noise, Shot noise, Quantization noise (uniform noise), Film grain, Anisotropic noise and Periodic noise. One of the noises commonly corrupting digital images is the impulse noise. Therefore, impulse noise reduction has become one of the active researches in these recent years [1]. Impulse noise appears as black and white speckles on the image [2]. According to the distribution of noisy pixel values, impulse noise can be classified into two categories: Fixed-Valued impulse noise and Random Valued impulse noise. The Fixed Values impulse noise is also known as Salt and Pepper noise, since the pixel value of a noisy pixel is either minimum or maximum value in grayscale images. Impulsive noise is sometimes called as salt-and-pepper noise or spike noise. It represents itself as arbitrarily occurring white and black pixels. An image that contains impulsive noise will have dark pixels in bright regions and bright pixels in dark regions. It can be caused by dead pixels, analog-to-digital converter errors and transmitted bit errors [3]. The goal of image denoising is to remove noise and to preserve more image details [4]. This paper reviews various papers of noise reduction techniques.

## II SURVEY METHODS ON IMAGE DENOISING

Amlan Kundu et al. [5] describe a method for removing impulse noise from images using Median filtering approach. This work is abbreviated as NR-MF, and the disadvantage is, when the noise corruption probability hikes its efficiency reduces.

Ho-Ming Lin et al. [6] reveal an algorithm for improving the impulse noise removal process using an adaptive window-size median filter which have a high degree of noise reduction. The image sharpness is also maintained, and it is abbreviated as NR-AWMF. The performance is poor for mixed impulse noise.

H. Hwang et al. [7] describe a method for removing impulse noise by adaptive median filter which have two variants namely Ranked-order Based Adaptive Median Filter (RAMF) and the impulse Size based Adaptive Median Filter (SAMF). The RAMF removes positive and negative impulses, and it is abbreviated as NR-RAMF. Herein, occurrence of artefact is the demerit.

Eduardo Abreu et al. [8] describe a new efficient approach for the removal of impulse noise based on rank-ordered mean filter, and it is abbreviated as NR-ROMF. Here, increment in computational complexity is the disadvantage of this method.

D. Zhang et al. [9] describe a method for noise detection and removal, using fuzzy techniques which works based on two techniques namely fuzzy impulse detection and fuzzy noise cancellation. Herein, it is abbreviated as NR-FT, and the best restoration results are obtained after two or three iterations.

Zhou Wang et al. [10] reveal an algorithm to remove impulse noise from corrupted images using Long-Range Correlation. This algorithm is abbreviated as NR-LRC. The disadvantage of this method is that it cannot perform well when noise ratio is high.

Tao Chen et al. [11] reveal a novel nonlinear filter, called Tri-state Median Filter and, the standard median filter and the center weighted median filter are involved. Herein, it is abbreviated as NR-TSM , and here edges are not preserved.

Piotr S. Windyga [12] proposes a generic-dimensional filter via recursive nonlinear filter to eliminate the impulsive noise, and it is abbreviated as NR-GDF which has a slight smoothing effect on non-noisy image regions.

F.J. Gallegos-Funes et al. [13] propose a new method known as Median M-type K-nearest neighbour filter, that uses R and M estimators. Herein, it is abbreviated as NR-MKN and the disadvantage of this method is that it consumes much time.

Gouchol Pok et al. [14] propose a decision-based, signal adaptive median filtering algorithm which works based on two stages. Herein, it is abbreviated as NR-DSAM. The false noise detection is very low and that is the disadvantage.

M. Emin Yukselet et al. [15] describe a method for efficient blur reduction during impulse noise removal operation using Neuro-Fuzzy Impulse Detector. Herein, it is abbreviated as NR-NFID and training is a must one which is the disadvantage.

Igor Aizenberg et al. [16] put-forth a new filter for impulsive noise removal using threshold Boolean filtering, and it is abbreviated as NR-TBF which consumes more time.

S.Q.Yuan [17] proposes a different-type noise detector for adaptive median filter, and it is abbreviated as NR-DDAM which consumes much time and this is the disadvantage.

Deng Ze-Feng [18] proposes a novel open-close sequence filter to remove impulse noise in highly corrupted images which consists two filters using open-close sequences, and the disadvantage is that it is used to restore images that are corrupted by 30%–80%., and it is abbreviated as NR-OSF.

A.S. Awad et al. [19] put-forth a high performance detection filter for impulse noise removal using four-phase noise detection technique. The random valued impulse noise is solved using a window size of 5x5 pixels and it is abbreviated as NR-HPD which restores images with blur.

Zhengya Xu et al. [20] reveal a geometric features-based filtering technique which is very useful for online applications to suppress impulse noise which is abbreviated as NR-GFF. Herein, the occurrence of block artifacts is the demerit.

Siti Noraini Sulaiman et al. [21] reveal a clustering-based segmentation algorithm which has three variations namely, Denoising-based-K-means, Denoising-based-Fuzzy C-means and Denoising-based-Moving K-means. This work is abbreviated as NR-CBS and the disadvantage is not applicable to images which are corrupted by more than 50% of Salt-and-Pepper noise.

Zhengya Xu et al. [22] describe a modified decision based unsymmetrical trimmed median filter algorithm for the restoration of gray-scale, and color images , and this work is abbreviated as NR-UTM. The disadvantage is that it is ineffective for salt and pepper noise removal in images at low noise densities.

Zhe Zhou [23] puts-forth an algorithm for impulse noise removal with uncertainity via weighted fuzzy mean filter which is based on cloud model. It is abbreviated as NR-CMF and the disadvantage is that it can only detect the fixed-valued impulse noise.

Lianghai Jin et al. [24] describe a new quaternion vector filter for removal of random impulse noise in color video sequences. Herein, it is abbreviated as NR-QVF and Video chromaticity changes are not clearly explained in this algorithm.

Faruk Ahmed et al. [25] describe a novel adaptive iterative fuzzy filter for denoising images corrupted by impulse noise and the two steps of algorithm are Detection of noisy pixels with an adaptive fuzzy detector and Weighted mean filter. Herein, it is abbreviated as NR-AIF and the disadvantage is that it is not applicable for huge noise level.

Tian Bai et al. [26] reveal a method for automatic detection and removal of high-density impulse noises, that consists of the two parts like impulse detection part and the impulse noise removal part, and it is abbreviated as NR-AD. The disadvantage is that it can remove the impulse noise only from less than ninety percent noise corruption level.

Ruixuang Wang et al. [27] describe a method to remove random-valued impulse noise with varying sizes and irregular shapes, and it is abbreviated as NR-RVI which has a rotation process that may introduce sampling errors.

Chun Lung Philip Chen et al. [28] describe, a weighted couple sparse representation model to remove impulse noise, and the image pixels are classified into clear, slightly corrupted, and heavily corrupted ones. Herein, it is abbreviated as NR-WCS and it cannot be used for color image.

Yi Wang et al. [29] propose a novel adaptive fuzzy switching weighted mean filter to remove salt-and-pepper noise, which involves dual stages viz. noise detection and noise elimination. Herein, it is abbreviated as NR-AFSW and it has the demerit of that the restoration quality is less.

Arpad Gellert et al. [30] present a image denoising method for impulse noise in greyscale images using a context-based prediction scheme, which is abbreviated as NR-CBPF. The disadvantage is the computational time required is very high.

Xiaotian Wang et al. [31] propose a high quality impulse noise removal via non-uniform sampling and autoregressive modelling based super-resolution, and it is abbreviated as NR-USAM. The disadvantage is that the proposed method exhibits good denoising performance in a specific noise density range only.

Bernardino Roig et al. [32] put-forth a localised rank-ordered differences vector filter for suppression of high-density impulse noise in colour images, and it is abbreviated as NR-VF. The demerit is that the computational complexity is high.

Amarjit Roy [33] puts-forth a combination of adaptive vector median filter and weighted mean filter for removal of high density impulse noise from colour images, and it is abbreviated as NR-AVM. The disadvantage of this method is that the computational complexity is increased.

Qing-Qiang Chen et al. [34] describe an effective and adaptive algorithm for pepper-and-salt noise removal, and it is abbreviated as NR-EAA. This noise-detection process achieves high correct-detection and low false-alarm rates.

Karen Panetta et al. [35] describe a New Unified Impulse Noise Removal algorithm using a new Reference Sequence-to-Sequence Similarity Detector, and it is abbreviated as NR-RSSS. This new detector will generate a flag matrix showing the position of noisy pixels.

Vikas Singh et al. [36] describe an Adaptive Type-2 Fuzzy Approach for Filtering Salt and Pepper noise in gray scale images, and it is abbreviated as NR-ATF. The computational time is relatively higher and this is the demerit of this method.

Samsad Beagum Sheik Fareed et al. [37] put-forth a fast adaptive and selective mean filter for the removal of high-density salt and pepper noise, and it requires only a minimum of one or two good pixels in the nearest neighbourhood for restoration. Herein, it is abbreviated as NR-SMF and it consumes much time for high-density salt and pepper noise removal.

V.P. Ananthi et al. [38] describe a impulse noise detection technique based on fuzzy set, and it is abbreviated as NR-FS. In low noise level it is not much effective.

Kyong Hwan Jin et al. [39] propose a Sparse and Low-Rank Decomposition of a Hankel Structured Matrix for impulse noise removal, and herein, Texture patterns are preserved. This work is abbreviated as NR-SLRD. This algorithm is called as robust ALOHA.

M. Monajati [40] describes a Modified Inexact Arithmetic Median Filter for removing Salt-and-Pepper noise from gray-level Images using histogram based error dispersion plot, and this method is abbreviated as NR- MIAM which has the disadvantage of that the quality of the image is very low.

Jiayi Chen et al. [41] describe an Adaptive Sequentially Weighted Median Filter for removing impulse noise, and the demerit of this filter is that no significant superiority in computational time. Herein, it is abbreviated as NR-ASWM.

Ugur Erkan et al. [42] propose an Iterative Mean Filter (IMF) to eliminate the salt-and-pepper noise using a window size of 3×3 that preserves the structure and edge information. The demerit of this method is that the random-valued impulse noise cannot be removed, and this method is abbreviated as NR-IMF.

Xiaoqin Zhang et al. [43] describe an Exemplar-based image denoising algorithms for image restoration, which uses a Unified Low-rank Recovery Framework. Herein, this method is abbreviated as NR-EB and this work is intolerant against artifacts.

Zhongtao Luo et al. [44] describe a novel design of nonlinearity pre-processor for impulsive noise suppression, and this method is robust and used for communication and radar systems, which is abbreviated as NR-NP. This method is intolerant against artifacts.

Qianqian Liu et al. [45] describe a nonlinear spline adaptive filter based on the robust Geman-McClure estimator. Herein, it is abbreviated as NR-SAF and the demerits of this method is the low speed and cannot be applicable for low magnitude noise.

The author Qi Wang et al. [46] describe a denoising scheme based on fractional differential theory, and it is abbreviated as NR-FDT. The demerit of this method is the creation of Local distortion in enhanced images.

Lianghai Jin et al. [47] describe an image recovery method based on deep convolutional neural networks for impulse noise removal, which consists of two components such as a classifier network and a regression network, and this work is abbreviated as NR-DCNN.

Chunwei Tian et al. [48] describe an Deep Convolutional Neural Networks (DCNNs) for image denoising, and it is abbreviated as NR-MDNN. The growth of the depth in deep networks may result in performance degradation and it is the disadvantage of this method.

C. Jaspin Jeba Sheela et al. [49] describe an efficient denoising of impulse noise from MRI using adaptive switching modified decision based unsymmetric trimmed median filter Herein, it is abbreviated as NR-DMRI. This work is intolerant against artifacts.

## III ANALYSIS AND DISCUSSION

**Table 1: Analysis on merits, demerits and MSE**

| S.NO. | METHODS | MERIT | DEMERIT | MSE |
|---|---|---|---|---|
| 1 | NR-MF | Fast execution | As the probability of noise corruption increases its performance decreases | 674.6529 |
| 2 | NR-AWMF | Image sharpness is preserved | Performance is poor for mixed impulse noise | 653.2515 |
| 3 | NR-RAMF | Sharpness of the images are preserved | Occurrence of artefact | 528.5431 |
| 4 | NR-ROMF | Improved restoration performance | Increase in computational complexity | 522.4929 |
| 5 | NR-FT | Subjective quality is very good | Best restoration results are obtained after two or three iterations | 528.5431 |
| 6 | NR-LRC | Visual qualities of the restored images are good | Perform worst when noise ratio is high | 522.4929 |
| 7 | NR-TSM | Preserves the image details and suppresses the impulse noise effectively | Edges are not preserved | 524.9046 |
| 8 | NR-GDF | Slight smoothing effect on non-noisy image regions | Excessively contaminated | 520.0923 |
| 9 | NR-MKN | Restoration performance is better | Consumes much time | 516.5120 |
| 10 | NR-DSAM | Can detect almost all noise | False noise detection is very low | 508.2535 |
| 11 | NR-NFID | Reduces the blurring effects | Detector must be trained using computer generated artificial images | 510.5995 |
| 12 | NR-TBF | Solve the edge preservation problem | Consumes more time | 501.2800 |
| 13 | NR-DDAM | Computational complexity is smaller | Consumes much time | 503.5938 |
| 14 | NR-OSF | Highly noise corrupted images | Images corrupted by 30%–80% impulse noise only can be used | 490.9988 |
| 15 | NR-HPD | Color images can also be restored | Restored images are blur | 494.4022 |

| | | | | |
|---|---|---|---|---|
| 16 | NR-GFF | Very useful for online applications | Occurrence of block artifacts | 482.0370 |
| 17 | NR-CBS | Preserves the important features on digital image | Not applicable to Images which are corrupted by more than 50% of Salt-and-Pepper noise | 475.4232 |
| 18 | NR-UTM | Images that are highly corrupted by salt and pepper noise images are used here. | Ineffective for salt and pepper noise removal in images at low noise densities | 467.8217 |
| 19 | NR-CMF | Texture details and the edges are preserved even for 95% noise level images | Only detect the fixed-valued impulse noise | 438.6119 |
| 20 | NR-QVF | Outperforms in terms of both objective measure and visual evaluation | Video chromaticity changes are not clearly explained | 419.8367 |
| 21 | NR-AIF | Even at the noise level 97% the performance is good | Not applicable for noise greater than 97% | 415.9876 |
| 22 | NR-AD | Perfect performance in terms of both quantitative evaluation and visual quality | Can remove the impulse noise only from less than 90% noise corruption level | 411.2259 |
| 23 | NR-RVI | Particle noise in hydro-colonoscopy images are effectively removed | Sampling errors occur | 378.5127 |
| 24 | NR-WCS | Preserves more image details and texture information | Method cannot be used for color image | 365.6625 |
| 25 | NR-AFSW | Keeps more texture details and is better at removing SAP noise and depressing artifacts | Restoration quality is less | 371.6040 |
| 26 | NR- CBPF | Significant advantage on images containing textures | Computational time required is very high | 332.7212 |
| 27 | NR- USAM | Image edges and details are preserved | Performance is not good if the noise density goes beyond the range 10%-90% | 358.1628 |
| 28 | NR-VF | Retain details of fine lines and edges | Computational complexity is high | 317.7462 |
| 29 | NR- AVM | High density impulse noise can be removed | Computational complexity is increased | 302.7474 |
| 30 | NR- EAA | Achieves high correct-detection | Low false-alarm rates | 310.5135 |
| 31 | NR- RSSS | Ability to accurately locate the positions of noise, retain edge information | Computational complexity is high | 282.5403 |

| | | | | |
|---|---|---|---|---|
| 32 | NR- ATF | Edges are preserved | Computational time is relatively higher | 288.4566 |
| 33 | NR- SMF | Best quality of images are produced | Consumes time for high-density salt and pepper noise removal | 274.8403 |
| 34 | NR- FS | When the level of noise is high denoising method is more efficient | In low noise level it is not much effective | 309.7993 |
| 35 | NR- SLRD | Texture patterns are preserved | Intolerant against artifacts | 261.2645 |
| 36 | NR- MIAM. | Effectively low cost in power, area, and speed | Quality of the image is very low | 228.0765 |
| 37 | NR-ASWM | Preserves the structure and edge information | Not applicable for real-time image denoising | 256.4959 |
| 38 | NR-IMF | Preserves the structure and edge information | Random-valued impulse noise cannot be removed | 235.0068 |
| 39 | NR-EB | Texture of the image is preserved | Intolerant against artifacts | 239.9277 |
| 40 | NR-NP | Robust and used for communication and radar systems | Intolerant against artifacts | 225.9854 |
| 41 | NR-SAF | Good stable performance against the impulsive noise | Low speed and not applicable for low magnitude noise | 227.5519 |
| 42 | NR-FDT | Edges and texture of the image are preserved | Local distortion of the enhanced image | 169.0754 |
| 43 | NR-DCNN | Excellently removes impulse noise | Noise levels from 10% to 60% only be denoised | 219.8267 |
| 44 | NR-MDNN | Texture and edges of the image is preserved | Performance degradation | 173.8123 |
| 45 | NR-DMRI | Used for noise reduction in gray scale MR Images | Intolerant against artifacts | 155.2675 |

The Table 1 describes the merits of the 45 image denoising methods. It also reveals the demerits of the concerned noise reduction methods. This table involves with the values of the standard metric namely MSE. The MSE computes the measure of closeness of the two images viz. Original image $I_{OI}$ and Noise-free image $I_{NFI}$using Equation (1).

$$MSE = \frac{1}{h*w}\sum_{i=0}^{H-1}\sum_{j=0}^{W-1}(I_{OI}^{i,j} - I_{NFI}^{i,j})^2 \quad (1)$$

The lesser-value of MSE means better denoising.

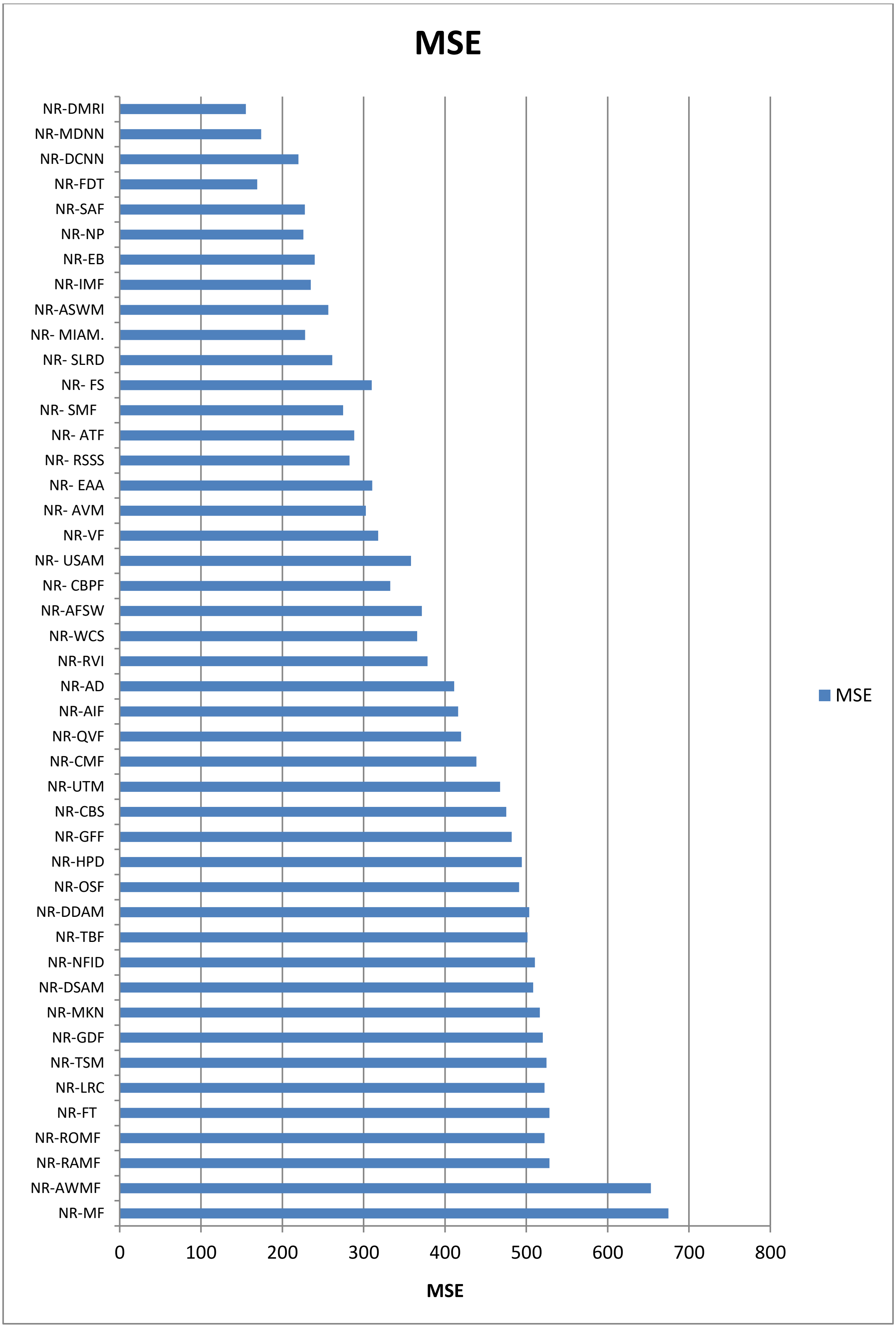


Fig.1: Chart for MSE analysis.

The Figure 1 depicts the MSE analysis for the entire 45 image-denoising methods. The low

MSE provider is the NR-DMRI method. The lowest MSE obtained by this method is 155.2675 for 60% noise corruption. The high MSE provider is NR-MF method which acquires the value of 674.6529.

**Table 2: Analysis on denoising algorithm and input image type**

| METHOD | PUBLICATION | YEAR | AUTHOR NAME | DE-NOISING TECHNIQUE | APPLICABLE IMAGE TYPES |
|---|---|---|---|---|---|
| NR-MF | IEEE | 1984 | Amlan Kundu et al. | Adaptive window | Grey scale |
| NR-AWMF | IEEE | 1988 | Ho-Ming Lin et al. | Adaptive window-size median filter | Grey scale |
| NR-RAMF | IEEE | 1995 | Jorge D. Mendiola-Santibanez et al. | RAMF andSAMF | Grey scale |
| NR-ROMF | IEEE | 1996 | Eduardo Abreu et al. | Rank-ordered mean filter | Grey scale |
| NR-FT | IEEE | 1997 | D. Zhang et al. | Fuzzy techniques | Grey scale |
| NR-LRC | IEEE | 1998 | Zhou Wang et al. | Long-Range Correlation | Grey scale |
| NR-TSM | IEEE | 1999 | Tao Chen et al. | Nonlinear filter, called tri-state median (TSM) filter | Grey scale |
| NR-GDF | IEEE | 2001 | Piotr S. Windyga | Recursive nonlinear filter | Real images |
| NR-MKN | IEEE | 2002 | F.J. Gallegos-Funes et al. | Median M-type K-nearest neighbour (MM-KNN) filter | Real images |
| NR-DSAM | IEEE | 2003 | Gouchol Pok et al. | Decision-based, signal adaptive median filtering | Real images |
| NR-NFID | IEEE | 2004 | M. Emin Yukselet et al. | Neuro-Fuzzy Impulse Detector | Real images |
| NR-TBF | IEEE | 2005 | Igor Aizenberg et al. | Threshold Boolean filtering | Real images |
| NR-DDAM | IEEE | 2006 | S.Q. Yuan | Adaptive median filter | Real images |
| NR-OSF | IEEE | 2007 | Deng Ze-Feng | Open-close sequence filter | Grey scale |
| NR-HPD | IEEE | 2008 | A.S. Awad et al. | High performance detection filter | Grey scale |
| NR-GFF | IEEE | 2009 | Zhengya Xu et al. | Geometric features-based filtering | Grey scale |
| NR-CBS | IEEE | 2010 | Siti Noraini Sulaiman et al. | Clustering-based segmentation | Grey scale |

| | | | | | |
|---|---|---|---|---|---|
| NR-UTM | IEEE | 2011 | Zhengya Xu et al. | Unsymmetrical trimmed median filter | Both gray-scale and color images |
| NR-CMF | IEEE | 2012 | Zhe Zhou | Cloud model filter | Grey scale |
| NR-QVF | IEEE | 2013 | Lianghai Jin et al. | Quaternion vector filter | Color video images |
| NR-AIF | IEEE | 2014 | Faruk Ahmed et al. | Adaptive iterative fuzzy filter | Grey scale |
| NR-AD | IET | 2015 | Tian Bai et al. | Newton–Thiele filter | Grey scale |
| NR-RVI | IEEE | 2015 | Ruixuang Wang et al. | Low-rank matrix | Grey scale |
| NR-WCS | IEEE | 2015 | Chun Lung Philip Chen et al. | Weighted Couple Sparse | Grey scale |
| NR-AFSW | IEEE | 2016 | Yi Wang et al. | Adaptive fuzzy switching weighted mean filter | Grey scale |
| NR- CBPF | IET | 2016 | Arpad Gellert et al. | Context-based prediction scheme | Grey scale |
| NR-USAM | IET | 2016 | Xiaotian Wang et al. | Non-uniform sampling and autoregressive modelling based super-resolution | Grey scale |
| NR-VF | IET | 2016 | Bernardino Roig et al. | Localised rank-ordered differences vector filter | Colour images |
| NR- AVM | IET | 2016 | Amarjit Roy | Adaptive vector median filter and weighted mean filter | Colour images |
| NR- EAA | IET | 2017 | Qing-Qiang Chen et al. | Effective and adaptive algorithm | Grey scale |
| NR- RSSS | IEEE | 2018 | Karen Panetta et al. | Weighted median filter | Grey scale |
| NR- ATF | IEEE | 2018 | Vikas Singh et al. | Type-2 fuzzy filter | Grayscale Images |
| NR- SMF | IET | 2018 | Samsad Beagum Sheik Fareed et al. | Adaptive and selective mean filter | Grey scale |
| NR- FS | IET | 2018 | V.P. Ananthi et al. | Hankel Structured Matrix | Grey scale |
| NR- SLRD | IEEE | 2018 | Kyong Hwan Jin et al. | Switching median filter | Grey scale |
| NR-MIAM. | IEEE | 2019 | M. Monajati et al. | Inexact Arithmetic Median Filter | Grey scale |
| NR-ASWM | IEEE | 2019 | Jiayi Chen et al | Adaptive Sequentially Weighted Median Filter | Grey scale |

| | | | | | |
|---|---|---|---|---|---|
| NR-IMF | IEEE | 2019 | Ugur Erkan et al | Iterative Mean Filter | Grey scale |
| NR-EB | IEEE | 2019 | Xiaoqin Zhang et al. | Exemplar-based | Hyperspectral Digital |
| NR-NP | IEEE | 2019 | Zhongtao Luo et al. | Novel Nonlinearity Based | Grey scale |
| NR-SAF | IEEE | 2020 | Qianqian Liu et al. | Novel spline adaptive filtering | Grey scale |
| NR-FDT | Elsevier | 2020 | Qi Wang et al. | Fractional differential gradient | Grey scale |
| NR-DCNN | Elsevier | 2020 | Lianghai Jin et al. | Deep convolutional neural networks | Grey scale |
| NR-MDNN | Elsevier | 2020 | Chunwei Tian et al. | Deep convolutional neural networks | Gray scale MR Images |
| NR-DMRI | Elsevier | 2020 | C. Jaspin Jeba Sheela et al. | Adaptive switching MDBUTMF filter | Gray scale MR Images |

The Table 2 tabulates the publishing-related-information, the names of denoising algorithms and the types of input images, involved in image denoising. Majority methods support grey scale images while limited methods supports color images. This survey declares that the NR-DMRI method is the best one among the entire 45 existing methods considered by this analysis.

## IV CONCLUSION

This review paper focuses on the image denoising techniques to understand the positive and negative things of the concerned methods. This paper constructs an extended survey via 45 existing methods. These 45 recent papers are selected from the state-of-the-art journals to reveal the pre-eminent survey. This survey analyzes the denoising accuracy using MSE metrics. The merit and demerits are tabulated to assess the adaptability of those methods with specific type of digital images. The NR-DMRI method yields lowest MSE value which indicates that the NR-DMRI method is the best image denoising for salt and pepper noise. The NR-FDT method is the second best method which provides a better level MSE. The algorithms involved in those 45 papers are expressed in the survey. The input image types are also handled here to have better knowledge. This survey is the best one to understand the existing denoising methods to employ it as a pre-processing task.

Reference

[1] Mandar D. Sontakke and. Meghana S. Kulkarni, “Different types of noises in images and noise removing technique”, International Journal of Advanced Technology in Engineering and Science, vol. 03, issue 1, January 2015.

[2] D. Van De Ville, M. Nachtegael, D. Van derWeken, E. E. Kerre, and W.Philips, “Noise reduction by fuzzy image filtering”, IEEE Trans. Fuzzy Syst., vol. 11, no. 4, pp. 429–436, Aug. 2001.

[3] Alisha P B and Gnana Sheela K, “Image Denoising Techniques-An Overview”, IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), vol. 11, issue 1, pp. 78-84, 2016.

[4]J. Canny, “A computational approach to edge detection”, IEEE Trans. Pattern Anal. And Mach. Intell., vol. 8, no. 6, pp. 679–698, Nov. 1986.

[5] Amlan Kundu, Sanjit K Mithra and P.P.Vaithiyanathan, “ Application of Two-Dimensional Generalized Mean Filtering for Removal of Impulse Noises from Images”, IEEE Transactions on acoustics, speech, and signal processing, vol. 32, issue 3, pp.600 – 609, 1984.

[6] Ho-Ming Lin and Alan N Willson, “ Filters with adaptive length”, IEEE Transactions on circuits and systems, vol. 35, issue 6, pp.675 – 690, 1988.

[7] H. Hwang and R. A. Haddad, “Adaptive median filters new algorithms and results”, IEEE transactions on image processing, vol. 4, issue 4, pp.499 – 502, 1995.

[8] Eduardo Abreu, Michael Lightstone, Sanjit K. Mitra and Kaoru Arakawa, “A new efficient approach for the removal of impulse noise from highly corrupted images”, IEEE Transactions on image processing, vol. 5, issue 6, pp. 1012 – 1025, 1996.

[9] D. Zhang and Z. Wang, “Impulse noise detection and removal using fuzzy techniques”,IEEE Electronic Letters, vol. 33, issue 5, pp. 378 – 379, 1997.

[10] Zhou Wang and David Zhang, “ Restoration of impulse noise corrupted images using long-range correlation”, IEEE Signal processing letter, vol. 5, issue 1, pp. 4 – 7, 1998.

[11] Tao Chen, Kai-Kuang Ma, and Li-Hui Chen, “Tri-state median filter for image denoising”, IEEE Transactions on image processing, vol. 8, issue 12, pp. 1834 – 1838, 1999.

[12] Piotr S. Windyga, “Fast impulsive noise removal”, IEEE Transactions on image processing, vol. 10, issue 1, pp. 173 – 179, 2001.

[13] F.J. Gallegos-Funes, V.I. Ponomaryov, S. Sadovnychiy and L. Nino-de-River, “Median M-type K-nearest neighbour (MM-KNN) filter to remove impulse noise from corrupted images”, IEEE Electronics letters, vol.38, issue 15, pp. 786 – 787, 2002.

[14] Gouchol Pok, Jyh-Charn Liu, and Attoor Sanju Nair, “Selective removal of impulse noise based on homogeneity level information”, IEEE Transactions on image processing, vol.12, issue 1, pp. 85 – 92, 2003.

[15] M. Emin Yuksel and Erkan Besdok, “A simple neuro-fuzzy impulse detector for efficient blur reduction of impulse noise removal operators”, IEEE Transactions on fuzzy systems, vol. 12, issue 6, pp. 854 – 865, 2004.

[16] Igor Aizenberg, Constantine Butakoff and Dmitriy Paliy, “Impulsive noise removal using threshold Boolean filtering based on the impulse detecting functions”, IEEE Signal processing letters, vol.12, issue 1, pp. 63 – 66, 2005.

[17] S.Q. Yuan and Y.H. Tan, “Difference-type noise detector for adaptive median filter”, IEEE Electronics letters ,vol. 42, issue 8, pp. 454 – 455, 2006.

[18] Deng Ze-Feng, Yin Zhou-Ping and Xiong You-Lun, “High Probability Impulse Noise-Removing Algorithm Based on Mathematical Morphology”, IEEE Signal processing letters , vol. 14, issue 1, pp. 31 – 34, 2007.

[19] A.S. Awad and H. Man, “High performance detection filter for impulse noise removal in images”, IEEE Signal processing letters, vol. 4, issue 3, pp. 192 – 194, 2008.

[20] Zhengya Xu, Hong Ren Wu, Bin Qiu and Xinghuo Yu, “Geometric Features-Based Filtering for Suppression of Impulse Noise in Color Images”, IEEE Transactions on image processing, vol. 18, issue 8, pp. 1742 – 1759, 2009.

[21] Siti Noraini Sulaiman and Nor Ashidi Mat Isa, “Denoising-based clustering algorithms for segmentation of low level salt-and-pepper noise-corrupted images”, IEEE Transactions on Consumer Electronics, vol. 56, issue 4, pp. 2702 – 2710, 2010.

[22] S. Esakkirajan, T. Veerakumar, Adabala N. Subramanyam, and C. H. PremChand , “Removal of High Density Salt and Pepper Noise Through Modified Decision Based Unsymmetric Trimmed Median Filter”, IEEE Signal processing letters, vol. 18, issue 5, pp. 287 – 290, 2011.

[23] Zhe Zhou , “Cognition and Removal of Impulse Noise With Uncertainty”, IEEE Transactions on image processing, vol. 21, issue 7, pp. 3157 – 3167, 2012.

[24] Lianghai Jin, Hong Liu, Xiangyang Xu and Enmin Song, “Quaternion-Based Impulse Noise Removal From Color Video Sequences”, IEEE Transactions on circuits and systems for video technology, vol.23, issue 5, pp.741 – 755, 2013.

[25] Faruk Ahmed and Swagatam Das, “Removal of High-Density Salt-and-Pepper Noise in Images With an Iterative Adaptive Fuzzy Filter Using Alpha-Trimmed”, IEEE Transactions on fuzzy systems, vol. 22, issue 5, pp. 1352 – 1358, 2014 .

[26] Tian Bai and Jieqing Tan, “Automatic detection and removal of high-density impulse noises”,IET Image Processing, vol. 9, issue 2, pp. 162 – 172, 2015.

[27] Ruixuang Wang, Markus Pakleppa and Emanuele Trucco , “Low-Rank Prior in Single Patches for Nonpointwise Impulse Noise Removal”, IEEE Transactions on image processing, vol. 24, issue 5 pp. 1485 – 1496, 2015.

[28] Chun Lung Philip Chen, Licheng Liu, Long Chen,Yuan Yan Tang and Yicong Zhou, “ Weighted Couple Sparse Representation With Classified Regularization for Impulse Noise Removal”, IEEE Transactions on image processing, vol. 24, issue 11, pp. 4014 – 4026, 2015.

[29] Yi Wang, Jiangyun Wang, Xiao Song and Liang Han, “ An Efficient Adaptive Fuzzy Switching Weighted Mean Filter for Salt-and-Pepper Noise Removal”, IEEE Signal processing letters , vol. 23, issue 11, pp. 1582 – 1586, 2016.

[30] Arpad Gellert and Remus Brad, “Context-based prediction filtering of impulse noise images”, IET Image Processing , vol. 10, issue 6, pp. 429 – 437, 2016.

[31] Xiaotian Wang, Guangming Shi, Peiyu Zhang, Jinjian Wu, Fu Li, Yantao Wang and He Jiang, “High quality impulse noise removal via non-uniform sampling and autoregressive modelling based super-resolution”, IET Image Processing , vol. 10, issue 4 , pp. 304 – 313, 2016.

[32] Bernardino Roig and Vicente D. Estruch, “Localised rank-ordered differences vector filter for suppression of high-density impulse noise in colour images”, IET Image Processing , vol. 10, issue 1, pp. 24 – 33, 2016.

[33] Amarjit Roy , Joyeeta Singha , Lalit Manam and Rabul Hussain Laskar, “Combination of adaptive vector median filter and weighted mean filter for removal of high-density impulse noise colour images”, IET Image Processing, vol. 11, issue 6, pp. 352-361, 2017.

[34] Qing-Qiang Chen, Mao-Hsiung Hung and Fumin Zou1, “Effective and adaptive algorithm for pepper-and-salt noise removal”, IET Image Processing, vol. 11, issue 9, pp. 709 – 716, 2017.

[35] Karen Panetta, Long Bao and Sos Agaian, “A New Unified Impulse Noise Removal Algorithm Using a New Reference Sequence-to-Sequence Similarity Detector”, IEEE Access, vol. 6, pp. 37225 – 37236, 2018.

[36] Vikas Singh, Raghav Dev, Narendra K. Dhar, Pooja Agrawal, and Nishchal K. Verma, "Adaptive Type-2 Fuzzy Approach for Filtering Salt and Pepper Noise in Grayscale Images", IEEE Transactions on fuzzy systems, vol. 26, issue 5, pp. 3170 – 3176, 2018.

[37] Samsad Beagum Sheik Fareed and Sheeja Shaik Khader, "Fast adaptive and selective mean filter for the removal of high-density salt and pepper noise", IET Image Processing , vol. 12, issue 8, pp. 1378 – 1387, 2018.

[38] V.P. Ananthi, P. Balasubramaniam and P. Raveendran, "Impulse noise detection technique based on fuzzy set", IET Signal Processing,vol. 12, issue 1, pp. 12 – 21, 2018.

[39] Kyong Hwan Jin and Jong Chul Ye, "Sparse and Low-Rank Decomposition of a Hankel Structured Matrix for Impulse Noise Removal", IEEE Transactions on image processing, vol. 27, issue 3, pp. 1448 – 1461, 2018.

[40] M. Monajati and E. Kabir, "A Modified Inexact Arithmetic Median Filter for Removing Salt-and-Pepper Noise from Gray-Level Images", IEEE transactions on circuits and systems—II: express briefs, pp. 1-1, 2019.

[41] Jiayi Chen , Yinwei Zhan, Huiying Cao, "Adaptive Sequentially Weighted Median Filter for Image Highly Corrupted by Impulse Noise", IEEE Access, vol. 7, pp. 158545 – 158556, 2019.

[42] Ugur Erkan , Dang Ngoc Hoang Thanh, Le Minh Hieu and Serdar Enginoglu, "An Iterative Mean Filter for Image Denoising", IEEE Access , vol. 7, pp. 167847 – 167859, 2019.

[43] Xiaoqin Zhang, Jingjing Zheng, Di Wang and Li Zhao, "Exemplar-based Denoising A Unified Low-rank Recovery Framework", IEEE Transactions on Circuits and Systems for Video Technology, Early Access Article, pp. 1 – 1, 2019.

[44] Zhongtao Luoand and Yangyong Zhang, "Novel Nonlinearity Based on Gaussianization and Generalized Matching for Impulsive Noise Suppression", IEEE Access, vol. 7, pp. 65163 – 65173, 2019.

[45]Qianqian Liu and Yigang He, "Robust Geman-McClure Based Nonlinear Spline Adaptive Filter Against Impulsive Noise", IEEE Access, vol. 8, pp. 22571 – 22580, 2020.

[46] Qi Wang, Jing Ma, Siyuan Yu and Liying Tan, "Noise detection and image denoising based on fractional calculus", ELSEVIER J. Vis. Commun. Image R, vol. 131, pp. 1-11, February 2020.

[47] Lianghai Jin, Wenhua Zhang, Guangzhi Ma , Enmin Song, "Learning deep CNNs for impulse noise removal in images", ELSEVIER J. Vis. Commun. Image R., vol. 62, pp. 193-205, July 2019.

[48] Chunwei Tian, Yong Xu, Zuoyong Li, Wangmeng Zuo, Lunke Fei and Hong Liu, "Attention-guided CNN for image denoising", ELSEVIER JRNL, vol. 124, pp. 117-129, April 2020.

[49] C. Jaspin Jeba Sheelaa and G. Suganthi, "An efficient denoising of impulse noise from MRI using adaptive switching modified decision based unsymmetric trimmed median", ELSEVIER Biomedical Signal Processing and Control, vol. 55, pp. 1-12, 2020.

Dr.K.K.Thanammal is currently working as an Associate Professor in the Department of Computer Science & Applications at South Travancore Hindu College, Nagercoil, Tamilnadu, India. She received Ph.D (Computer Science) & M.Phil(Computer Science)from Manonmaniam Sundaranar University, Tirunelveli, India, M.Sc(Computer Science) from Bharathidasan University, Thiruchirapalli, India. She passed SLET(2016) conducted by Mother Teresa University,

Kodaikanal, India. She has 26 years of teaching experience. She published 16 journals in various National and International journals. She is a research supervisor in Manonmaniam Sundaranar University. Her main areas of interest are Medical Image Processing, Artificial Intelligence, Data Mining and Neural Networks. She is acting as a board chairman for BCA and MCA board-of-studies in Manonmaniam Sundaranar University,Tirunelveli, India, since 2015 onwards.

V. Juliet Rani is working at St.Jerome's College, Nagercoil, Tamil Nadu, India, as an Assistant Professor. She received her MCA degree from Noorul Islam College of Engineering, Kumaracoil, Thucklay, Tamilnadu in 2003. She received M.Phil degree in Computer Science from Mother Teresa university,Kodaikanal, Tamilnadu, India, in 2004. She is a research scholar of Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, India.She has 12 years of teaching experience. Her research area is Medical Image Processing.Her area of interest is Data mining, Image processing and Internet of things.