AN EFFICIENT IMAGE NOISE ESTIMATION TECHNIQUE USING TYPE-2 FUZZY SET AND GENETIC ALGORITHM

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ABSTRACT

Noise estimation in digital images plays an important role in various kinds of applications such as medical imaging, video processing and communication systems. Noise density estimation from an image can help to analyze the channel properties of a communication system. Some authors have been described with a few algorithms to estimate noise present in the images in the spatial and frequency domain. The quality of a captured image through image acquisition devices like camera or sensor will not be noise free because of some parameters like circuit noise and atmosphere conditions. The main objective of this project is to evaluate the noise levels at different parts of the image with the help of a new algorithm Interval Type-2 Fuzzy Sets Filter (IVT2 FSs) and Genetic algorithm (GA). In this, we have estimated the performance in terms of the Structural Similarity Index Metric (SSIM), Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Noise Variation (NV).

Keywords: *Interval Type-2 Fuzzy Sets Filter, Genetic algorithm, Structural Similarity Index Metric, Peak Signal to Noise Ratio, Mean Square Error.*

1. INTRODUCTION

Image enhancement and the noise filtering are the major pre-processing steps in the digital image processing in various fields such as biomedical, photography, etc. These two tasks are very essential for image processing in the process of visual interpretation [1]. Many algorithms are reliable to image processing for estimation of noise levels in different parts of the images. The global illumination methods are one which used photo-realistic quality for generation of synthetic image generation. These methods completely depend on the stochastic paths which are generated by camera point of each pixel in the image [2]. Previously, linear filter has been used for image pre-processing to remove additional noise in the image. This Filter can preserve the edge and suppresses the noise. During this process, the data loss is the main limitation of the linear filter. The nonlinear filter has been used for edge preservation without any data loss. Due to the imperfection of camera points, the images commonly affected by noise. Impulse noise is mostly affected by memory location hardware, camera sensors and errors in the data transmission. Impulse noise is commonly classified into two types such as random valued shot noise and salt and pepper noise. In the random values shot noise, an arbitrary value can be assigned to the noisy pixels. The noised pixels took only minimum or maximum values when compared to the surrounding pixel if the image is having salt and pepper noise. So, it is a bit hard to remove these kinds of noise using linear filters. To overcome this problem, fuzzy set (FS) based filters [3] are used to analyze the pixel variations in the spatial domain by using a fuzzy rule set.

Operations of the FS filters can separate into three steps. In the initial step, fuzzy area width is determined from fuzzy homogeneity vectors by taking into account of the spatial gray-level dependence and represent the identical feature between a pixel and its near pixels. The gray level uncertainty is determined by transferring the original image to the fuzzy domain. In the second step, based on fuzzy area width, homogram and Shannon's function fuzzy entropy function was estimated. In the last step, depending upon the type of image, fuzzy region width is automatically adopted. The method can be used for many applications in image segmentation, thresholding, quality analysis [4]. Based on the type-2 fuzzy rule

system, the uncertainty of lively cutting forces for the micro milling machine was determined. With the sensor observations, we can also measure the instantaneous cutting force of the micro milling along with the noise estimation. Interval type 2(IT2) rule-based system gives much information regarding machine tool controller for its operation [5].

A new Type-2 fuzzy Gaussian Mixture Models (T2 FGMMs) were introduced for image noise estimation process and gives a good performance measure in denoising process. In this work, based on the spatial information of the pixels, the core region and the open region of the image were extracted. The GMM parameters of the core region and an open region were estimated with the support of the EM algorithm and finally. The Bayesian decision was applied on an image to get denoised image [6]. Ordinary filters were not able to eliminate the several types of noises, so to remove several kinds of noises classical filter has been introduced. It has the capability to remove the more than one type of noise from the images [7]. It is significant that routinely measure the quality of the image is precisely to characterize images of photographic quality. Many algorithms are a great concern in image compression (JPEG models) and in image synthesis. Image quality measures are usually divided into three models such as no reference [8], reduced-reference models and full reference (such as the SNR and measure SSIM [9]). Existing methods have some limitations such as low PSNR, SNR, SSIM and less optimized. The linear equalizer has been used for optimization with reference to the SSIM in the image restoration process [10]. The proposed method is going to overcome by optimizing significant peaks in each block separately with the different sets of chromosomes and gives better values of PSNR as well as SSIM values with the support of GA.

2. RELATED WORK

Samuel Delepoulle *et al.* [11] have showed the typical FS has included in image processing which is generally fuzzy numbers. FS defines the meaning demonstration of the vagueness related with a linguistic variable A in a natural language. However, it is not possible to say which Membership Function (MF) is the finest one. The amount of uncertainty is hard to compute in the instance of FS's, and specifically when images were degraded noise. The major enthusiasm of this article is to remove the uncertainty of membership values by using interval-valued FS's. Author algorithm has

explained the fixed values of the support value such as α =2 and 3.

Olivia Mendoza *et al.* [12] have showed the improvement of edge finders depends on the gradient measure with the support of IT2 fuzzy logic. The development is on the representation of vagueness in image gradients and their combination with the IT2 fuzzy integral. The insertion of uncertainty in gradients supports to find true edges which will be ignored with an alternative method. The method which was used in this article, to recognize shapes in images with very flexible contrast or in applications which necessity to find additional edges in images than the conventional methods. The aim of the author is to evaluate performance, the quality of the identified edges with conventional and enhanced edge detectors was measured by Pratt's figure of merit with synthetic images.

Samuel Delepoulle *et al.* [13] have proposed an innovative no-reference image content metric, based on type-2 FS's. It does not need any earlier knowledge about the trial image or noise. Entropy value drops monotonically either when the image becomes distorted or noisy. Therefore, it would be useful in the detection of noise as well as blur. With reference, image quality degree is frequently expensive to obtain the results. This is the main drawback of Computer-Generated Images (CGI) use of global illumination methods. The key aim of global illumination methods is to produce CGI with photorealistic quality. To this tenacity light interaction and photon propagations with the matter have to be precisely simulated.

Peng Ye *et al.* [14] have addressed the difficult of general-purpose No-Reference Image Quality Assessment (NR-IQA) with the intention of emerging a real-time, cross-domain model which can forecast the quality of unfair images without former knowledge of undistorted reference images and sorts of distortions present in these images. The model has following components: (1) a local feature extractor; (2) a global feature extractor and (3) a regression model. The earlier methodologies typically treat local feature extraction and regression model training individually. The author proposed a focused method upon back-projection, which relates the two phases by the knowledge a dense set of filters which would be applied to the local image areas to get discriminative local features. With the support of a small set of filters, the projected method was tremendously fast. They have tested this model on several natural scene and

document image datasets and found the accurate results.

Miguel Fidalgo-Fernandes *et al.* [15] have explained the quality estimation model with the location, spatial and content factors content on the perception of quality. The major content of an image is the area where impairments might have more impact on the definition of quality. The disposition of the impairments and their global location should have a strong influence. The quality estimation by machine learning methods was based on the SSIM evaluation locally in small cells.

3. PROPOSED METHODOLOGY

The proposed method is going to minimize the MSE and noise variance but it increases PSNR and SSIM value of the CGIs. Let g be the noise corrupting image which is additive, unvarying and has zero mean (i.e., white noise):

$$G(m.n) = g(m,n) + \eta(m,n) \qquad (1)$$

From Eqn (1) g (m, n) is the ideal image. G (m, n) is the observed image and η is the noise density component. The aim is to calculate the variance var(η) of η. Many researchers were presented algorithms to evaluate the features of noise in binary images. These methods attack the evaluation problem in one of the two ways

1. By filtering G to suppress the image structure and then evaluating var(η) from the filtered data

2. By evaluating var(η) from the variance of G, in a set of image regions initially classified as showing little structure.

This project is offering a method to fit the first family among two, starting from the smoothing of the image G. With the ultra-fuzziness index, new image filters were introduced for image denoising. Local and global properties of the pixels have been achieved by using this kind of filter. In this project presenting this index for effective measure noise level in the CGIs and for images noise estimation. The new image J can be obtained after the filtering noise of the image G.

The uncertainty of Membership function (MF) of a specific FS is demonstrated with the support of interval δ(x) in an Interval Type-2 Fuzzy Set (IVT2FS). Uncertainty is more for longer interval δ(x). Due to this reason selection of MF is greatly important. The proposed method for image de-noising and noise evaluation with GA is explained in forthcoming discussions.

Let us define Gaussian fuzzy number is defined as

$$\mu(t;n,\sigma) = \exp\left[\frac{-1}{2}\left(\frac{t-n}{\sigma}\right)^2\right] \qquad (2)$$

$$upper\ limit : \mu_U(t) = \left[\mu(t;n.\sigma)\right]^{1/\alpha}$$

$$lower\ limit\ \mu_L(t) = \left[\mu(t;n,\sigma)\right]^{\alpha}$$

$$\alpha = 2$$

In noise power estimation of the CGIs using IVT2FS filter, we need to consider two parameters such as fuzziness degree and entropy are given by Eq. 3, & 4. These parameters support to measure the uncertainty in fuzzy logics.

Now let us define IVFS imprecision degree Ind (A) of an IVFS

$$Ind(X) = \sum_{j=1}^{n}\left[\mu_U(t_j) - \mu_L(t_j)\right] \qquad (3)$$

Define another parameter index of fuzziness

$$\Gamma(t) = \frac{1}{AxB}\sum_{t=0}^{N-1}h(t)\left[\mu_U(t) - \mu_L(t)\right] \qquad (4)$$

The eq(3) shows the movement of IVT2FS over the interval [0,N 1] of the histogram of the image by changing j with keeping σ fixed. MAX(Γ) is computed for all the blocks, for image X Γ(t) increases as image turn to be less noisy and which is used for further noise estimation.

Fig. 1 shows the block diagram of the proposed algorithm. The previous algorithms noise suppression was not achieved up to the extent and has high MSE along with less PSNR. The proposed algorithm is achieving the best PSNR and minimized MSE by GA and by optimizing the significant peaks with different sets of chromosomes. In the proposed algorithm, image G of size AxB is divided into Ki patches of size MxN and calculates the histogram of each patch. After calculating the histogram of the image, initialize MF's on image and repeat the calculation of MF's for index n as showed in the eq(2). By using the MF's, calculating the Γk(n) using eqn(4) and this will be repeated for all the patches. Apply interval value FS filter for optimizing the significant peaks of each block with different sets of chromosomes by using GA. This also optimizes the SNR as well as PSNR of the image. The algorithm gives the good estimation of the noise power, SNR and

PSNR of the image, from this we achieve the noise   free image.
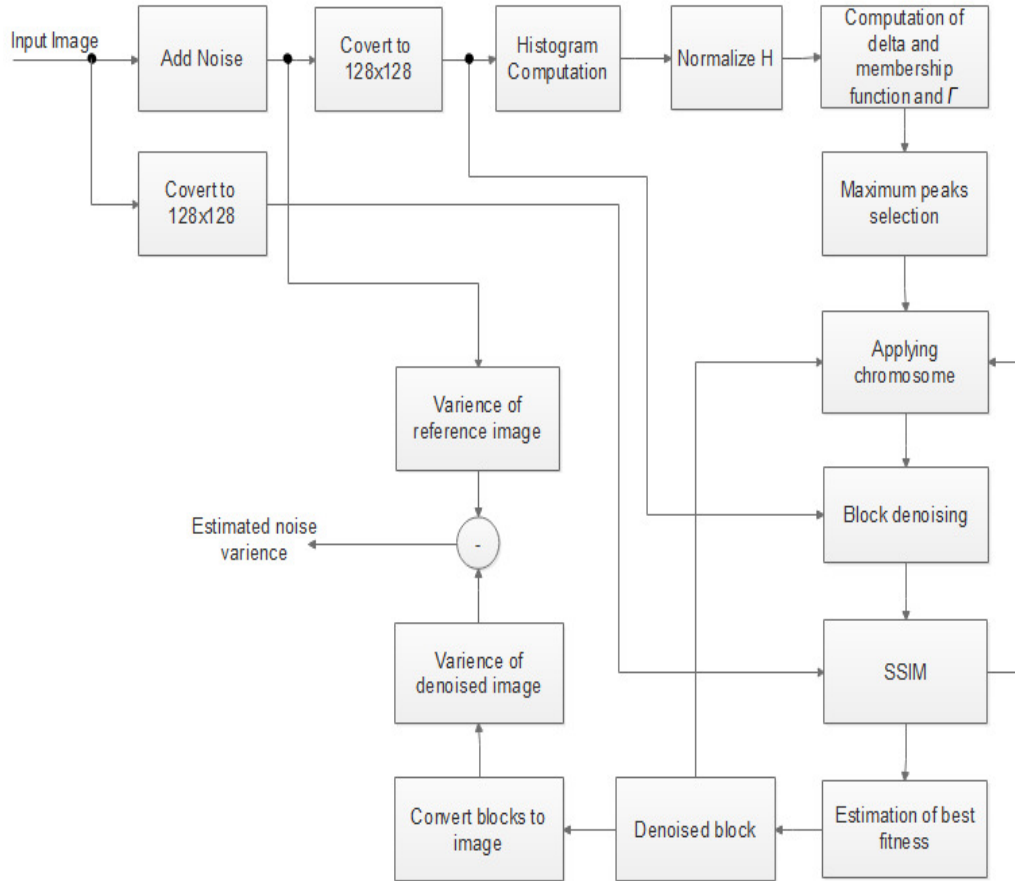

Figure 1: Block diagram of proposed method

The fig. 1 describes the block diagram of the proposed methodology. Initially, image G of size MxN is spitted into K blocks using MATLAB function and calculate the histogram for each block and normalized to 1. Set the position of MFs With the use of normalized histogram values and compute the entropy of each block. After calculate the $\Gamma(t)$ for each block from equation (4), find the maximum peaks of the image. Once we obtained the maximum peaks then apply the chromosome set to each block for de-noising of the image and compute SSIM of each block. Here we have chosen 10 chromosome set for denoising of the each block, and each set is applied to patch to denoise the image

and find the fitness function. This will be repeated for all 10 set of chromosomes and applying chromosome set we gives the high SSIM value. Once one patch is denoised then move to the next patch. Like this all patches denoised and combined at the end. To obtain the noise variance, all the blocks are converted back to image with the support of MATLAB function and estimate the variance of noise-free image J as well variance of noised image G and the noise variance is obtained by subtracting J from G with the help of subtraction unit as shown in fig 1. Along with noise estimation, we also estimate the PSNR as well SNR of the images.
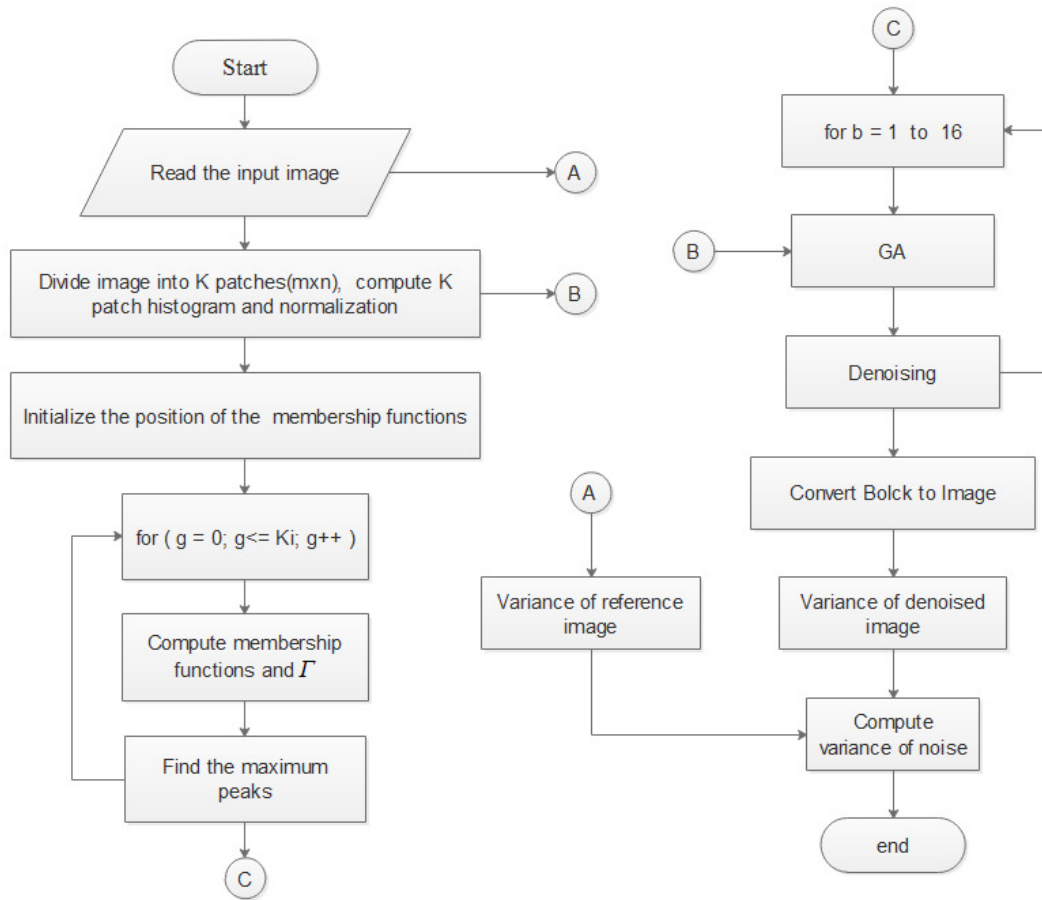
Figure 2: Flow Chart For Noise Estimation Algorithm Using IVFS Filter

The fig.2 shows the flow chart for the noise estimation algorithm using IVFS filter, here input image is noisy image and this noise can be eliminated by using an efficient GA based IVFS filter. By using different set of chromosomes, the noise free image are obtained and estimated the performance of the system.

Algorithm: Genetic algorithm

Input image: A x B gray level image G

Divide the image G into K sub-patches of size p x q

Choose the shape of the MF

Find the image histogram of each patch and normalized to1

Initialize the position of the MF

Move the MF on the gray-level range

for n = 0 to N− 1

  do

for t = 0 to N − 1

do

Compute $\mu(t;n,\sigma)$

Compute $\mu_U(t)\ and\ \mu_L(t)$

Compute $\Delta_n(t) = h(t)\left[\mu_U(t) - \mu_L(t)\right]$

end for

Compute $\Gamma t = \dfrac{1}{AxB}\sum_{n=0}^{N-1}\Delta_n(t)$

end for

Find the maximum peaks in each block

for b = 1 to the number of blocks

do

    if Number of peaks >= length(CS)

for CS = 1 to maxCS

do

Apply chromosome for block

end for

Obtain de-noised block

else

Normal operation

end if

Update the maximum fitness value

end for

Estimate the best fitness

Convert block to image

Estimate variance of de-noise image J and reference image G and variance of noise = G – J.

4. EXPERIMENTAL SETUP

The proposed method was implemented in MATLAB version R2015b to obtain the variance of noise that was present in the CGIs. The complete work was done by using the I7 system with 8 GB RAM. A different set of chromosomes was applied to each block of the image to obtain the best values of PSNR and SSIM.

5. RESULTS AND DISCUSSION

Fig 3 shows the histogram of the noised image and noise free image. Significant peaks are optimized with the support of the GA with different chromosome sets.
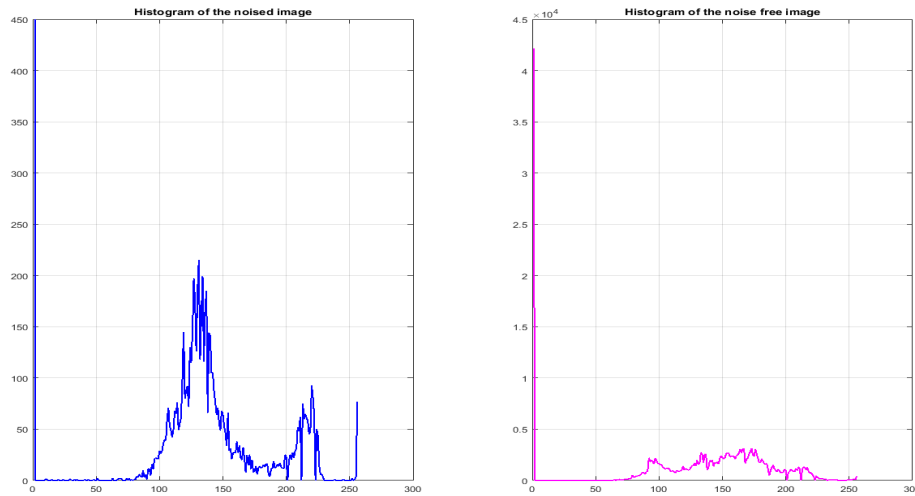

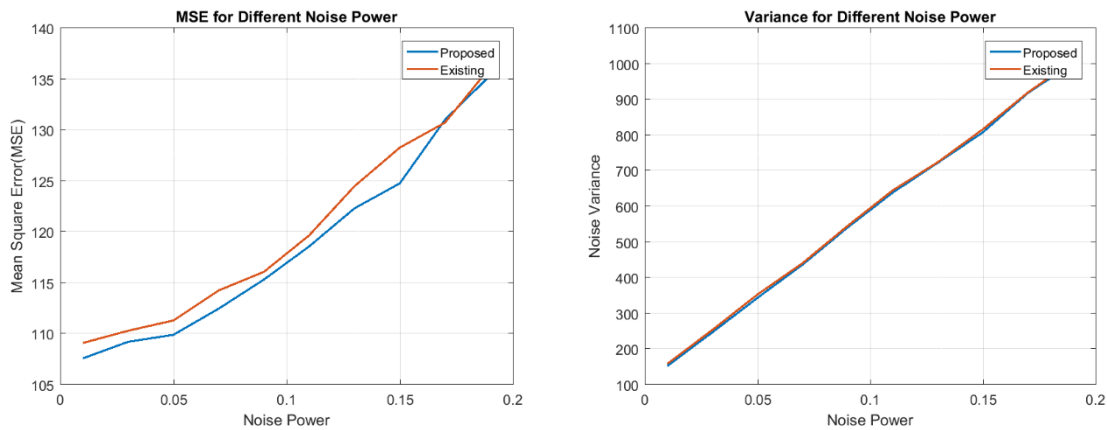*Figure 3: Histogram Of The Noised Image And Noise Free Image*

Figure 4 (A): Comparison Of MSE Value
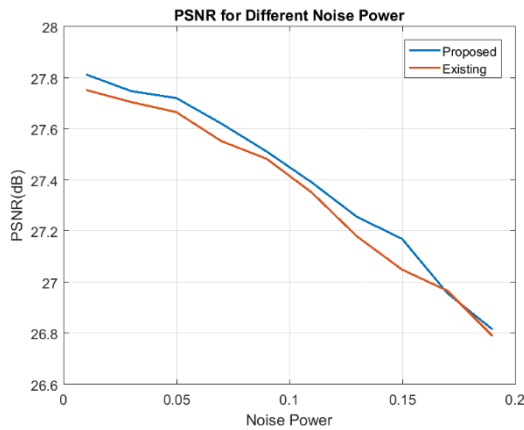
Figure 4 (B): Comparison Of Variance Value
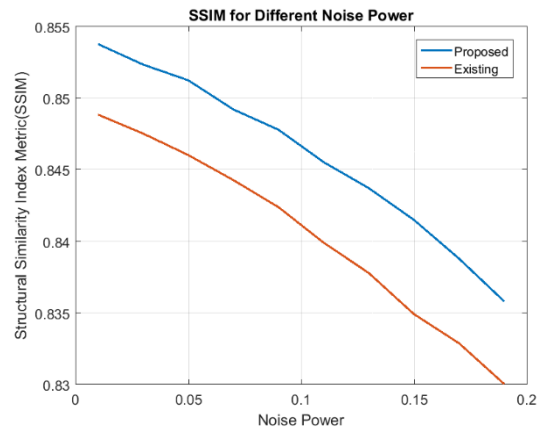
Figure 5 (A): Comparison Of PSNR Value

Figure 5 (B): Comparison Of SSIM Value

The overall performances are shown in fig.4. (a), fig.4. (b), fig.5. (a) and fig.5. (b). The proposed MSE value and noise estimation values is less compare to the existing method, which is shown in fig.4. (a) and fig.4. (b). Similarly, PSNR value and SSIM value of the proposed method have been increased than existing method, which is shown in fig.5. (a) and fig.5. (b).

Table 1: Comparison Of MSE, PSNR, SSIM, And Estimated Noise Value

	MSE		PSNR		SSIM		Estimated Noise	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
0.01	65.92596	65.67860	29.94024	29.95656	0.895633	0.89655	115.7104	107.340925
0.03	67.40151	67.32653	29.84411	29.84894	0.894461	0.89483	134.1964	123.274188
0.05	69.35318	69.46431	29.72014	29.713185	0.892227	0.89297	146.2483	142.02615
0.07	72.14763	73.33001	29.54858	29.47798	0.888592	0.88941	170.0633	155.06343
0.09	77.19776	78.13882	29.25476	29.20213	0.884395	0.88540	188.5345	183.68444
0.11	83.21779	81.27634	28.92864	29.03116	0.879343	0.88209	226.1083	204.66577
0.13	91.43701	89.84548	28.51958	28.59584	0.874763	0.87600	244.3328	229.94657
0.15	102.0534	98.79759	28.04253	28.18334	0.867233	0.86971	262.3792	253.15002
0.17	107.6436	109.40571	27.81092	27.74040	0.862304	0.86418	299.5864	296.18779
0.19	114.5801	114.4440	27.53971	27.54487	0.856317	0.85826	334.7575	302.06969

According to table.1, MSE value has been be reduced and PSNR value is inversely proportional to MSE. Similarly, SSIM values also compared to analyze the percentage of structural distortion happened in the image.
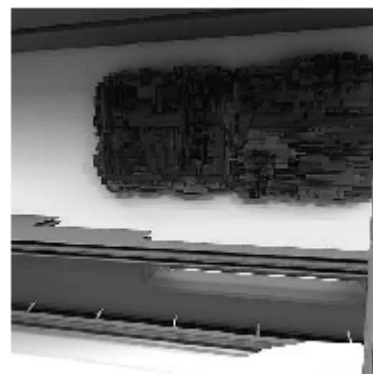

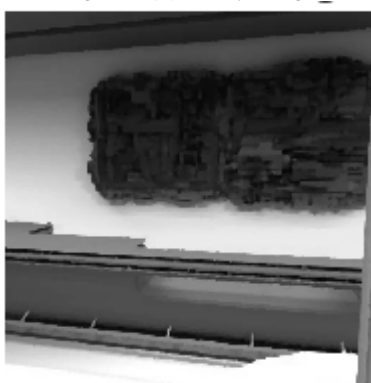*Figure 6 (A): Input Image*
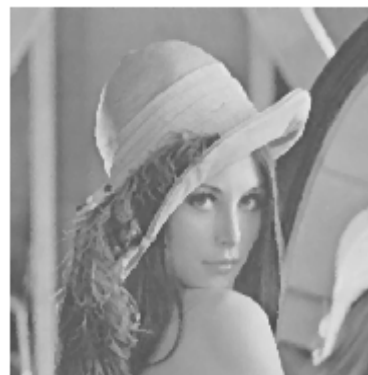
*Figure 6 (B): Noisy Image_*

Figure 7 (C): Output Lena Image

The Fig.6 (a) shows the noise free image in gray level with minimum pixel value of 0 and maximum of 255. Fig.6 (b) is the noisy image used as input to perform denoising by proposed method. Denoised image by using proposed method is shown in Fig.6 (c). The same process has been done in the Lena image that results are shown in fig.7 (a), fig.7 (b), and fig7 (c).

6.   CONCLUSION

In this paper, we have proposed a new algorithm to improve the noise estimation of digital images with the support of IVT2FS filter and Genetic algorithm. The algorithm has been analyzed with different kind of images with various noise densities. Similarly, proposed algorithm was analyzed with different fuzzy rule set as well as a different number of iterations. From the obtained results, we can conclude that noise estimation performance of the proposed algorithm is better when compared to the other methods with respect to the parameters like MSE, PSNR and SSIM values.

Figure 6 (C): Output Image

Figure 7 (A): Input Lena Image

Figure 7 (B): Noisy Lena Image

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