ROLE OF TRANSFORMS FOR IMAGE DENOISING

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By

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DECLARATION BY THE SCHOLAR

I hereby declare that the work reported in the M-Tech thesis entitled **"ROLE OF TRANSFORMS FOR IMAGE DENOISING"** submitted at **Jaypee University of Information Technology, Waknaghat, India,** is an authentic record of my work carried out under the supervision of **MR. PARDEEP GARG**. I have not submitted this work elsewhere for any other degree or diploma.

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CERTIFICATE

This is to certify that the work reported in the M. Tech thesis entitled **"ROLE OF TRANSFORMS FOR IMAGE DENOISING"** which is being submitted by **Aarushi Kapil** in fulfillment for the award of Master of Technology in Electronics and Communication Engineering by the Jaypee University of Information Technology, is the record of candidate's own work carried out by her under my supervision. This work is original and has not been submitted partially or fully anywhere else for any other degree or diploma.

01/05/17

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(AARUSHI KAPIL)

LIST OF ACRONYMS & ABBREVIATIONS

DCT	Discrete Cosine Transform
DFT	Discrete Fourier Transform
WT	Wavelet Transform
CWT	Continuous Wavelet Transform
DWT	Discrete Wavelet Transform
DST	Discrete Shearlet Transform
MRA	Multiresolution Analysis
MSE	Mean Square Error
PSNR	Peak Signal to Noise Ratio
SAR	Synthetic Aperture Radar
LMS	Least Mean Square
DOST	Discrete Orthonormal Stockwell Transform
MATLAB	MATrix LABoratory
CT	Computed Tomography
FT	Fourier Transform
MRI	Magnetic Resonance Imaging
ST	Stockwell Transform
STFT	Short Time Fourier Transform
JPEG	Join Photographic Experts Group

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ABSTRACT

An image is a value thousand words and in this digital Era, image's are all over the place. There is a massive number of numerical data being originated in the subject of images. But there is a primary concern with images. Mostly, the numerical images include of several noises that noise is originated, whether in image achievement or broadcast because of certain reasons. Eliminating noise from numerical noise is an immense task for the researchers working in the numerical image processing field. The considerable figure of growth and Research has been done and the various process has been outlined till now. This paper is a determination at the revision of the research publicity put prominence in the new ancient times. The Noise elimination from images in numerical processing is the most important concern. Impulsive noise is one a certain noise which might corrupt images at the time of their attainment, or broadcast, or storage etc. The papers acknowledgment certain dissimilar images denoising skills have been roofed and their element has been shortened. Eliminating noise for any prepared image is very necessary noise that must be removed in such a way that the vital information of must is conserved. Even now a what's a challenging issue for researchers is to eliminate the noise from the real signal. Image noise is a casual difference of color info in image's or brightness and is usually a feature of electronic noise. It can be invented by the circuits of a scanner and sensor or the digital camera. Image noise is an unwanted by product of image capture that adds false and inappropriate info. Image noise can also be originated in film grain and in the compulsory shot noise of an ideal photon detector. There have been massive published algorithms and each accession has its expectations qualities and confines.

CHAPTER 1

INTRODUCTION

Image reestablishment has a very momentous role in Digital Image Processing. This involves researchers in an algorithm happening and acts goal adapted to image processing. Image reconstructions are the elimination or lesser of decline that is experienced as any image is received. Degeneration arrives as of disorientation in addition to noise because of the photometric and electronics sources[1]. A set frequency range fall of an image happened through the faulty image construction activity for example qualified signal among actual scene and the camera or through a visual structure that is absence of the target is called blurring . while airborne images be created for distant discovery objectives, smudges are brought in by distinctive disorder, abnormalities in that visual structure comparative reason between the ground and the camera. Apart from these distorted things, noise has been ruined the noted image. The noise is made known through transferring mode because of a noisy channel fault while the determination procedure and while quantization of the information for numerical loading. Every component in the image group like in digitizer, lens, film, etc donates to degeneration. Image denoising is usually spent in area of publishing and photographs in which images were someway deprived other than required to upgraded ahead of it is published. The mode for the appliance, they have to recognize somewhat regarding deprivation procedure arranged to establish figure of it. If we are having figure for degeneration procedure, converse procedure could be enforced to image which will save to actual form. This method of image reinstallation is usually used in space investigation to help reduce artifacts originated to pay damages for misrepresentation in the visual structure of a contracter. Image de-noising looks appliances in an area as in astronomy in which promise confines is work , in medical images in which the physical needs for best class image is required for examining the image of particular happening , in science where the possibly make use of photographic proofs is sometimes of very poor quality [2] . Now acknowledge the image of a numerical image. A 2- structural numerical image can be presented as a 2- structural point of info s(a, b), where (a,b) presented the pixel position. The pixel expense compares to the illumination of the image at position(a,b). Several of the highly commonly used image modes are gray scale, binary, and color images. Binary images are the uncompleted mode of images and can only have two separate rates, white and black. Black is presented with the rate’0’whereas white with’1’. It is to note down that; the binary image is usually made with a gray-scale image. A binary image looks appliance in computerized visualization field where the overall figure or expressed data of the image is required. They are too known as 1 bit/pixel images. Gray-scale images are called as one- color or monochrome. The images that are exhausted for testing aims in this paper are all gray scale images. They have no data. They present the light of the images. This image consists 8 pixel/bits info, which meant it can possess till 256 (0-255) various lights levels. A ‘0’ presents black and ‘255’ presents white. In between rate 1 to 254 presents the various gray stages. As they consist the power data, they are too known as power images. Color images are measured like tri-band solo chrome images, where every band is a separate color. Every band offers the light data of the parallel spectral band. Particular color images are green, blue, and red images and are too called RGB images.

1.1 Types of Noise

In this, we introduced noise usually exist in an image. It is to be noted noise can displeasing data i.e. spoiled image. Image in de-noising procedure, data relates the form for noise exist in actual images played crucial task. Particular images are ruined within noise assigned to whether uniform, Gaussian and salt & pepper division. The other particular noise is a speckle noise that has multipliable feature. Noise exists in an image whether in an additional or multipliable kind.

The noise that is additional present follows the rule,

$Z(\text{a, b}) = M(\text{a, b}) + N(\text{a, b})$……………………….(1)

Whereas the multipliable noise follows,

$Z(\text{a, b}) = M(\text{a, b}) \times N(\text{a, b})$………………………..(2)

In which M(a, b) is the actual signal, N(a, b) presents the noise made known into the signal to obtain the ruined image Z(a, b), and M(a, b) presents the pixel position. The upper image algebra is made at pixel stage. The Additional image also looks appliances in image special effects [3]. By multipliable image, we meant the light of the image is different. The numerical image achievement procedure transmits a visual image in constant electrical indication which is comes in examples [3]. In each move in procedure, these are changes occurred through normal experiences, additionally a casual price to the original light rate for a prescribed pixel.

1.1.1 Gaussian Noise

Gaussian noise is equally divided across signal. Which means every bit within distorted figure is total of true accurately bit rate and usual Gaussian divided clatter rate. This noise have Gaussian division, in which it shows bell figure chances divided purpose [3]. Clearly, it is presented as a displayed in Fig 1.1. if discussed into an image, Gaussian noise having one value and variation as 1.05 will finds as in image 1.1 [4]. Image 1.2 demonstrate the Gaussian noise with variance as 1.05(5) over a root image with an endless bit rate of 101.

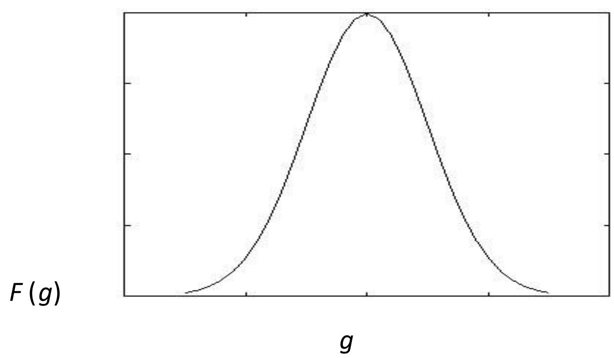


Fig 1.1: Graph of gaussian distribution

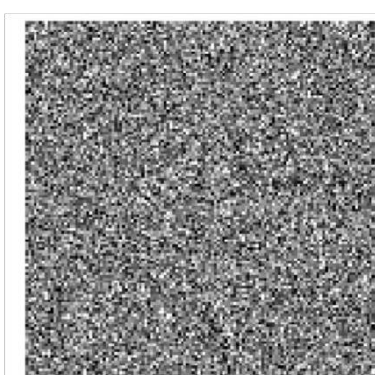


Image 1.1: Gaussian noise (mean=1, variance 1.05)

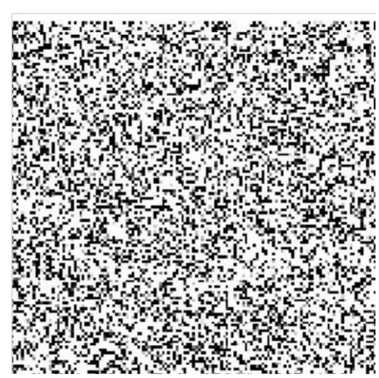


Image 1.2: Gaussian noise (mean=1.05, variance 5)

1.1.2 Salt & Pepper Noise

Salt & pepper noise is an instinct form of noise that is too called as strength points. This occurred usually because of faults in info transportation. It has two probable rates only, x and y. Chance of all is characteristic > 0.10. This ruined bites be group preferably towards least otherwise towards extreme rate, providing image "salt & pepper" similar look. Bits that unaltered left unaffected [3]. For the 8-pixel image, the characteristic rate is zero for pepper noise & 255 for salt noise. Pepper & salt clatter be usually occurred by defective of bit components with camera sensor, positions, defective remembrance, and timings faults within numerical procedure. Chances thickness works used for the form of noise as displayed into fig 1.2. Salt & pepper noise with a discrepancy of 1.10 is displayed in image 1.3[4].

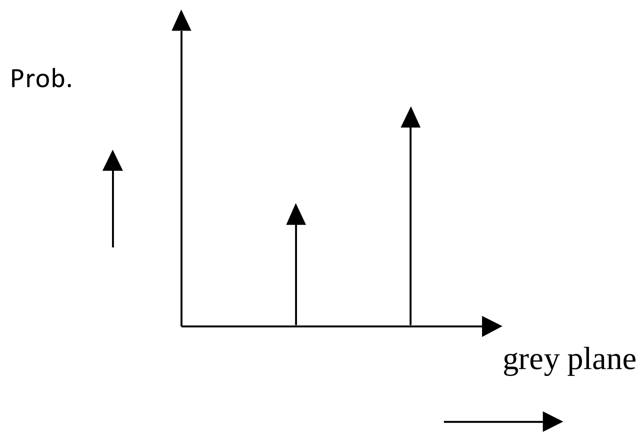


Fig 1.2: Graph for salt & pepper noise

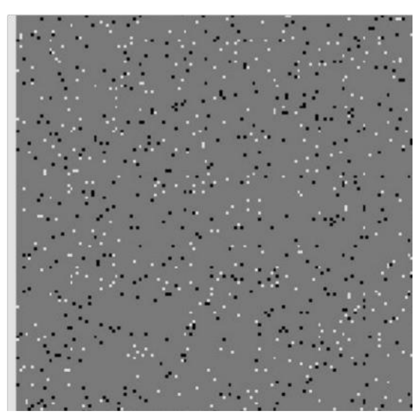


Image 1.3: Salt & pepper noise

1.1.3 Speckle Noise

Speckle noise is a multipliable noise. This form of noise happens in barely in almost all consistent imaging structure as in acoustics, laser, SAR images. The basis of this noise is credited to casual intrusion between the consistent reoccurrences. Totally established speckle noise has a feature of multiple noises. Speckle noise pursues a gamma division[5]. On that image, speckle noise by discrepancy 1.02 appears as displays in image 1.4. Gamma division is mentioned in fig 1.3.

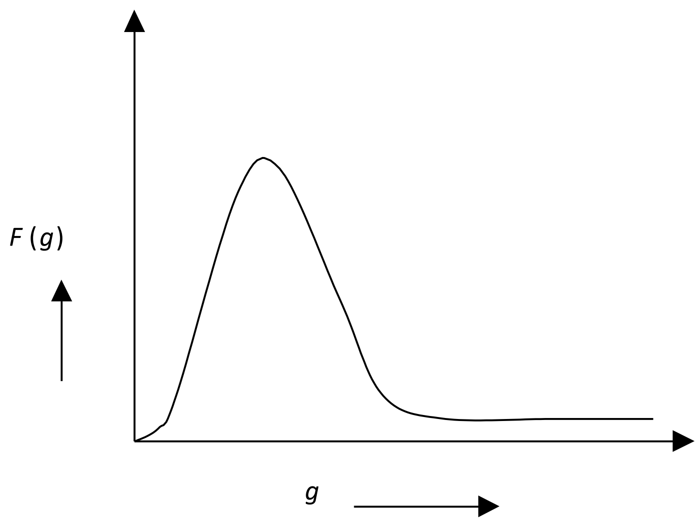


Fig 1.3: Graph of gamma distribution

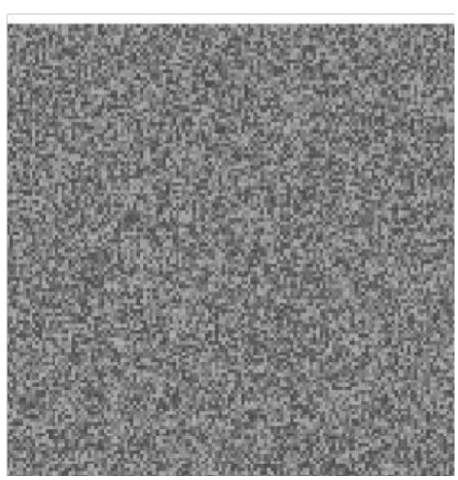


Image 1.4: Speckle noise

1.1.4 Brownian Noise

Brownian noise appears beneath the classification of fractal. Arithmetical figure for 1 divide by f noise is partial brownian signal [7]. Fractal brownian wave is a non-fixed assumed procedure that pursues a natural division. BN is an extraordinary incident of that noise [6]. It is generated through making one colorless noise. This is clearly presented as displayed in fig 1.4. on that image, the BN would appear as image 5 that is designed from Fraclab [8].

Fig 1.4: Brownian distribution

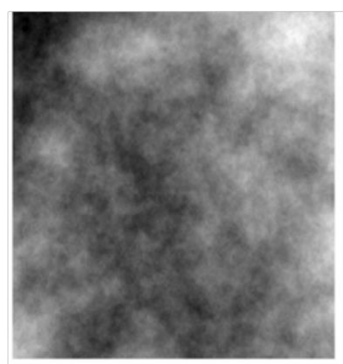


Image 1.5: Brownian noise

1.2 Linear and Nonlinear Filtering Approach:

Linear filtering makes use of unkind filters and lms adaptive modifying filter as well as non-linear filters located in midpoint filters has been introduced within the thesis. Furthermore, procedure of image de-noising is depicted in a view of MATLAB [9] execution.

1.2.1 Background

Filter shows vital task within image resaved procedure. This root idea at the back of image reinstallations by making use of linear filters in numerical complexity and moving window primary [10]. Let q(x) be key wave themed into filter and l(x) is desired outcome. When it fulfilled several conditions as in alteration invariance, afterward outcome delivered arithmetically within an uncomplicated type like,

$l(x) = \int q\ (t)\ g(x - t)\ dt,$……………………………………(3)

here $g(t)$ is known as mid spreading work or desire return which works totally features sift. This essential presents complexity essential thus can be defined as

$l = q * g.$

The distinct incident, essential converts within the synopsis like

$l(i) = \sum_{-\infty}^{+\infty} q(t)\, g(i - t)$……………………………………… (a)

After the bounds on the synopsis in example (a) are ∞, the task $h\ (t)$ is generally zero conclusion several variety. In case, the variety over which $g\ (t)$ is non-zero is $(-k,\ +k)$, then the upper example (a) can be expressed as

$l(i) = \sum_{i-k}^{i+k} q(t) g(i - t)$……... (b)

The eq. meant outcome l(i) at mid K is provided by an entire total key bits revolving K wherever complete provided by g(t). For making outcome of further bits i+l, the work $g(t)$ is moved by solo and the entire total is recalculated. The sum of outcome is made by a set of mover-multipliable- total function, and this creates a separate loop.

1.2.2 Linear Filtering

(A) Mean Filter

A mean filter mannerism on an image by scrapings it, that is, it shrinks the strength changes between contrary to bits. The mean filter is nonentity but a uncomplicated descending window spatial filter that substitute the mid rate in the window with the mean of all the adjacent bit rates containing its own [3]. With this, it substitutes bits,i.e. unnatural by its nearby. They are equipped within the loop ,who offers consequence i.e. appraised total of rate of bit or their surrounding. And is referred as a mean filter. Kernel and mask is four-sided figure. Usually, 3x3 cude essence has been exhausted. when constant for that cover summarizes as solo, after that means light for the image is not being transformed. when constants total as 0, mean light is misplaced, in that case comes back shady image. Arithmetic means sift functions lying on swing grow total theory [10]. The mask make use here is a 3x3 kernel displayed in fig 1.5.

1/9	1/9	1/9
1/9	1 /9	1/9
1/9	1 /9	1/9

Fig 1.5: A constant weight 3×3 filter mask

Calculating the easy loop of a image by the essence takes exposed average filter procedure. Mean filter mechanism is as little go by the sift or they do not permit higher frequency elements exist within noise to set off throughout. They keep in mind those bigger kernels of amount 5×5 or 7×7 offers extra de-noising but creates the image extra distorted. The skill inedible is to shaped among essence mass along with quantity for de-noising. Filter introduced upper is too called an endless stable sift as mass medium isn't alter in entire procedure. Linear filter is admired on behalf of its easiness & straightforwardness of carrying out. They executed mean sift by making use of MATLAB. The bit rate of an image "cameraman.tif" is comprehended into the program by making use of the work imread(). The mass of the image is 256x256 . Salt & pepper noise is joined with the image by making use of work imnoise(). This bit rate of the ruined image is photocopied hooked on two structural point of range 256x256. The 3x3 mass is modified. Choosing a 3x3 window above the 256x256 bit medium, the mass total of the chosen window is calculated. The result substituted the mid bit in the window. For more repetition, the window swings by solo column to the right. The window undertaking is treated in an aligned way first and then in a straight-up way till all the data is sheltered. The improved bit medium is now transferred to the image pattern with the help of the work imwrite().

(B) LMS Adaptive Filter

Primary difference between average filter and adjusting filter exist in the detail that mass medium differs later than every repetition in adjusting filter whereas it left's continuous all the time the repetition in the average filter. Adjusting filter is talented of de-noising non-permanent images, i.e. images which have an unexpected modification within strength. These filters be called in favor of their capacity within unconscious pursuit unfamiliar situations or when a wave is changing with less a priori understanding of the wave to be treated. Generally, an adjusting filter iteratively fits its limit while examining the image to match up the image obtaining instrument. This instrument is extra momentous in realistic images, which have a tendency in the direction of non-permanent. Evaluated toward additional adjusting filters, LMS adjusting filters are called for its straight forwardness in calculating and carrying out. The root figure is a linear mixture of a permanent less go by image and a non-permanent higher go by element via heaviness task [11]. That is why the work is given an agreement between the conclusion of real characteristics and repression of noise.

Image 1.6: Input to LMS adaptive filter

Image 1.7: Output from LMS adaptive filter

1.2.3 Non Linear Filtering

(A) Median Filter

The mid sift associated to non linear filters dissimilar to linear filters. These average filters too copy swing gap facts equivalent near the average sift. The 3x3, 5x5, or 7x7 kernels of bits is examined over bit medium of the full image. The mid of the bit rate in the window is calculated, and the mid bit of the window is substituted with the calculated mid. Mid filtering is done by, sizing all the bit rates from the revolving adjoining into an arithmetical arrangement and then substituting the bit being treated with the mid bit rate . Write down that the mid rate should be penned to a written to an unconnected point or shield so that the outcome is not ruined as the
procedure is produced. Fig 1.6 demonstrates the approach.

123	125	126	130	140
122	124	126	127	135
118	120	150	125	134
119	115	119	123	133
111	116	110	120	130

Fig 1.6: Basic model of median filtering

Neighborhood values:

115,119,120,123,124,125,126,127,150

Mid rate: 124

The mid- bite rate of 150 in the 3x3 window displays in model 6 is usual of the neighboring bits and is substituted with the mid bit of 124 . The mid is extra forceful assessed to the average. Thus, a solo very unusual bit in a surrounding will not concern the mid rate considerably. Since the mid rate should, in reality, be the rate of the solo of the bit in the surrounding, the average filter does not make latest improbable bit rate while sift strides a border. The mid sift is greatly improved the protective prompt border than the average filter. These benefits support mid filters de-noising unchanging noise as well from an image.

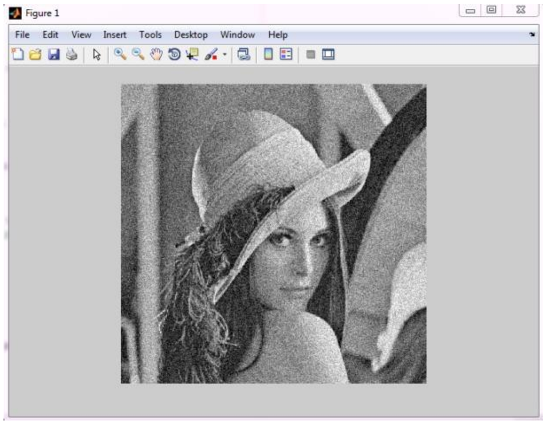


Image 1.8: input given to median filter

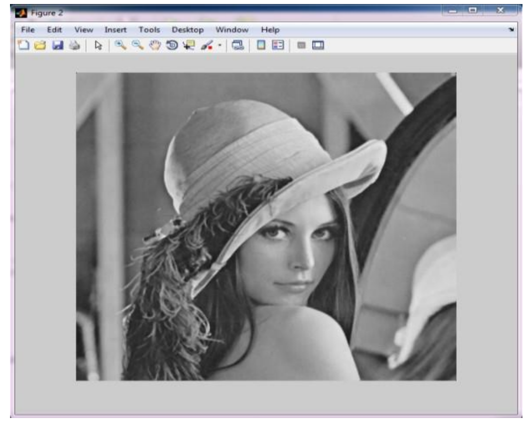


Image 1.9: Output through median filter

1. 3 Transforms used for Image Denoising:

A. Discrete Cosine Transform:

Image compression is a method in which quantity of information is reduced on behalf of sample digital images and as a result there is decrease in cost for transmission and storage. There are two types of compression techniques i.e. lossy and lossless compression techniques. Lossless compression techniques takes the compressed image and improve it to original image. Whereas in lossy compression the improvement in compressed image is almost same as the original image but it is not equal to it. In earlier days one quantization matrix was used in DCT compression, almost the jpeg standard. In DCT, various quantization matrics of coefficients are used. 2-D DCT of an image, fig. 1.7.

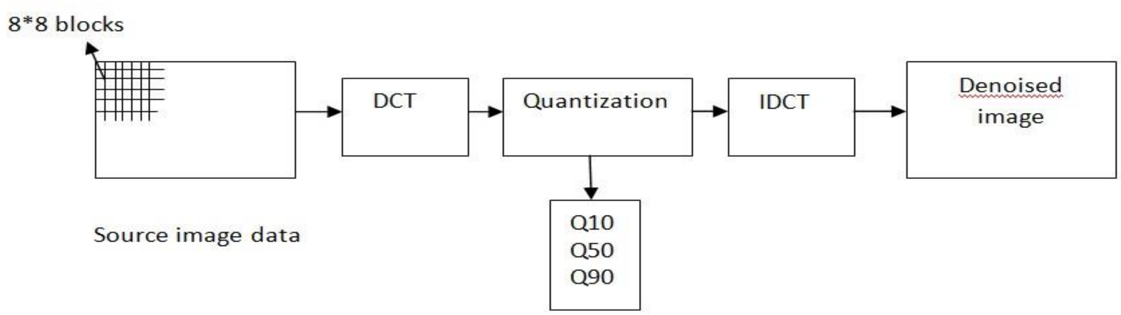


Fig 1.7: Block diagram of discrete cosine transform

B. Discrete Wavelet Transform:

The Discrete Wavelet Transform (DWT) of image signals creates a laid off image representation, which provides better spatial and spectral localization of image formation, compared with other multi -scale representations such as Gaussian and Laplacian pyramid. The DWT can be interpreted as signal decomposition in a set of independent, spatially oriented frequency channels. Recently, Discrete Wavelet Transform has attracted more and more interest in image de-noising. The signals are passed through two complementary filters and emerge as two signals, approximation, and Details. This is called decomposition or analysis[14]. The mathematical manipulation, which implies analysis and synthesis, is called discrete wavelet transform. The components can be assembled back into the actual signal without misplacing of data. This process is called reconstruction or synthesis. The fig. 1.8 shows the algorithm for DWT [9] .

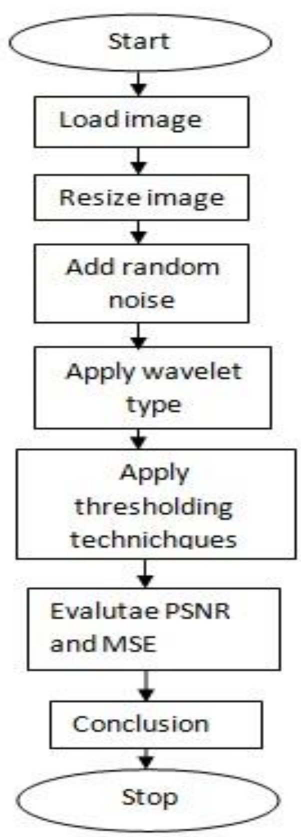


Fig 1.8: block diagram of discrete wavelet transform

C. Curvelet Transform:

The curvelet transform possesses superior presentation over local ridgelet converts nevertheless of the block size. The curvelet renovation doesn't hold an quantity of troubling artifact beside boundaries i.e. one can find in wavelet renovation. Undecimated wavelet transforms loom output a PSNR can be compared with curvelet transform. One can see the decimated wavelet transform displays alteration in limits along with experience a significant failure of mandatory aspect[12]. An examination of the details of the restored images is instructive. In fact, both wavelet reconstructions obscure structure in the hatband which was visually detectable in the noisy panel at upper left. In comparison, every structure in the image which is visibly noticeable in the noisy image is clearly presented in the curvelet reformation.

D. Stockwell Transform:

S-transform can offer instantaneous frequency and time allotment data equivalent to the wavelet transform and discrete orthonormal S-transform can reduce the redundancy of S-transform further. We first introduce the thought of WT based image denoising into discrete orthonormal stockwell transform domain and projected the thresholding-based image denoising using discrete orthonormal stockwell transform after that they use huffman coding in discrete orthonormal stockwell transform domain to compress the images. So they recommend a remedial image denoising and compress method using discrete orthonormal stockwell transform [13]. S- transform is a time-frequency analysis method proposed by R. G. Stockwell in 1996 , it inherits and develops the localization idea of continuous wavelet transform and short-time Fourier transform (STFT)[20]. Applications for fluoroscopic image and computed tomography image illustrate the high- quality presentation of the planned technique and explain their huge ability used for analytical images. Using S-transform we can get a more accurate relationship between the distribution of time and frequency of the signal. S-transform has been applied in signals processing domain successfully. Stockwell transform improves the time-frequency resolution of STFT and can be regarded as an expansion or superior case of wavelet transform (WT) in the multi-resolution analysis domain. To combat redundancy caused by S-transform, the discrete orthonormal S-transform (DOST) is proposed by R. G. Stockwell which makes S-transform much practical and extra suitable in real life[21]. For example, S-transform has been used in power quality to detect the disturbance and has also been applied to diagnose the type of fault and the faculty phase on overhead transmission line . Much of the research in using S-transform process medical image has examined the good performance of S-transform.

CHAPTER 2

OBJECTIVES OF THE THESIS WORK

- A complete survey of the image denoising techniques based on the essential characteristics of the image.
- To suggests the latest denoising method which helps in eliminating the noise.
- Replicate the suggestive solution in MATLAB.
- To access and examine the results.
- Evaluate the results of the recommended system with the present system.

CHAPTER 3

LITERATURE REVIEW

Jean-Luc et al. [12] brought in a much-uncomplicated introduction in Fourier time which demands cartesian examples and yields examples a rectoploar grid, which is a pseudo-polar exampling series placed on parallel squares geometry. Instead of the roughness of our interposition, the graphic presentation is unexpectedly great. Their ridgelet changes demands to the Radon changes a superior over complete wavelet pyramid whose wavelets have contract hold up in the frequency domain. Their Curvelet changes make use of our ridgelet change as a constituent move, and device curvelet sub bands by means of a filter bank of trous wavelet filters. Their thinking all the time is that changes must be over fulfilled, Rather than significantly examined. They claim these numerical changes to the denoising of certain level images installed in white noise.

Carine et al. [13] spoken of that S change is suitable well- popular for a time- frequency analysis and data-adaptive filtering credit to its clarity. While this change works completely in the constant domain, its separate version might fail to accomplish exact results. This thesis evaluates and disagreements this change with the well- known continuous wavelet change, and explains a connection between both. This correlation permits a well considerate of the S change and makes it promising to appoint the wavelet reconstruction formula as the latest reverse change and to recommend certain ways to resolve several of the chief drawbacks of the distinct S changes, such as its restraints to linear frequency exampling.

S.Kother et al. [14] mentioned that the image de-noising certainly ruined by noise is a conventional issue in the area of signal or image rectification. Extra chance noise can be without difficulty eliminated via easy threshold technique. De-noising of certain images ruined by Gaussian noise by wavelet skills is very successful because of its proficiency to catch the resources of a signal in fewer resources change worth. The wavelet de-noising system thresholds the wavelet constant proceeding from the level separates wavelet transform. In this thesis, it is recommended to examine the correctness of various wavelet bases and the capacity of the dissimilar neighborhood on the functioning of image de noising algorithm in conditions of PSNR.

Wang-Q et al. [15] establish the separate shearlet transform (DST) which implements successful multiscale directional presentation and show that the carrying out of the change in completed in the separate framework based on a multiresolution analysis (MRA). They evaluate the functioning of the DST in image de-noising and estimate applications. In image estimation, their estimate structure by the DST exceeds the separate wavelet transform (DWT) whereas the cyber price of their system is equivalent to the DWT. Also, in image de-noising, the DST evaluates auspiciously with other present Changes in the literature.

Paul et al. [16] imported that S-transform is a successful time- frequency examined skill which can maintain immediate time and frequency allocation data is same to the discrete wavelet transform and separate discrete orthonormal stockwell transform be capable of lessen unemployment of stockwell transform promote. therefore, they suggest a remedial image de- noising & reducing technique by discrete orthonormal stockwell transform. At firstly, they propose thought that wavelet transform placed image de-noising keen on discrete orthonormal stockwell transform area and recommend threshold occupying image de-noising through the medium of discrete orthonormal stockwell transform, after that they make use of huffman coding in discrete orthonormal stockwell transform field to decrease images. Appliances for fluoroscopic image and computed tomography images exemplify great functioning of recommended technique & explain their extreme ability used for analyzer images.

B.Niteesh et al. [17] mentioned that Tetrolet transform is a wavelet located inexpensive and successful change makes use of ropes shaped by linking tetrominoes which are four indistinguishable square uncertainty so as everyone be linked to each another cube with the boundaries. Haar wavelets have been described on the tetrominoes consequently to make a bounded orthonormal base. This process has been enforced on narrow separation of sparsest cover since every separation is kept non termination within wavelet assumption outcome in the sparse image presentation. Subsequently Peak reduction relative amount is gained behind the appliance of a wavelet reduction process on the Tetrolet constant. Here to decrease process price, several changes in the fundamental Tetrolet transform are also referred to. Tetrolet transform is a successful skill uses tetrominoes for image reduction with few edge blurring. The lessening in file size permits more images to be saved in a prescribed size of disk or memory space.

Vandana et al. [18] make known that Wavelet Transform has confirmed to be successful noise eliminator skill and also lessen cyber difficulty with great noise elimination functioning. This thesis states the diverse between image denoising through DWT and Framelet transform. Framelet transform offers shift invariance property. So, making use Framelet transform which is practically equivalent to the wavelet transform only with the dissimilarity is that framelet transforms having two or higher frequency filter bank that makes use of outgrowth more subbands in the breakdown.

CHAPTER 4

OUTLINE OF THE WORK

The fundamental thought at the back of this thesis work is to eliminate the noise in images and to reduce them successfully. In this, we will calculate the mean square error and PSNR. Our scheduled system is prearranged to discover and eliminate the noise by ways of various denoising transforms. And therefore, the issue is mentioned as "Role of transforms in image denoising". In the current paper activity, the third chapter throws lights on literature existing linked to practices spent in the current research paper. The next chapter represents the execution and the developmental results. At last, the last chapter ends about the judgment of the work and chances for further research in this field.

CHAPTER 5

METHODOLOGY

5.1 Discrete Cosine Transform:

Introduction:

Image compression is a method in which quantity of information is reduced on behalf of sample digital images and as a result there is decrease in cost for transmission and storage. There are two types of compression techniques i.e. lossy and lossless compression techniques. Lossless compression techniques takes the compressed image and improve it to original image. Whereas in lossy compression the improvement in compressed image is almost same as the original image but it is not equal to it. In earlier days one quantization matrix was used in DCT compression, almost the jpeg standard. In DCT, various quantization matrics of coefficients are used. calculated quantization matrix level is linked to the standard divergence of DCT's coefficient block.

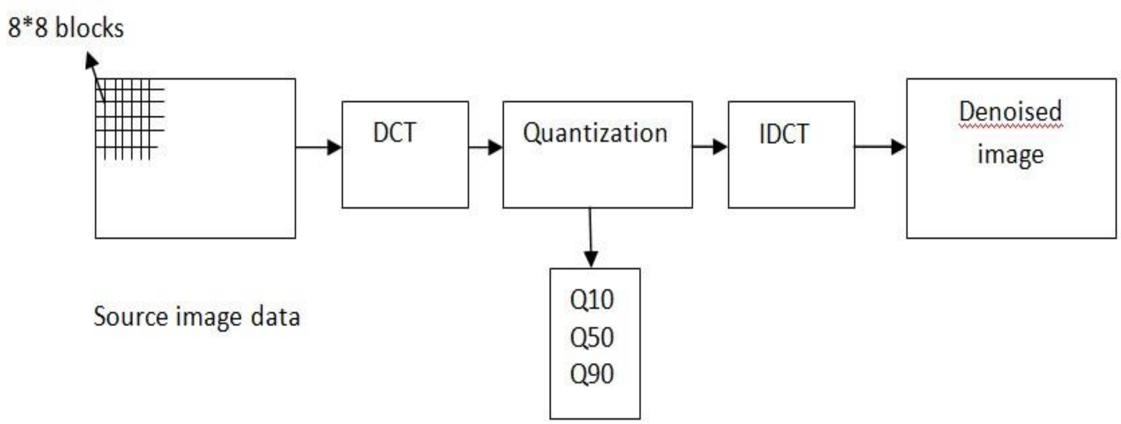


Fig 5.1 : Algorithm steps for DCT

5.2 Discrete Orthonormal Stockwell Transform:

Introduction:

Here in the signal & image processing, a signal is decomposed into its frequency component by fourier transform. Although the universal advantage of fourier transform every sample makes an FF each fourier cum collateral it is adverse in operations wherever limited data is endorsed. For example: phase analysis, compression, signal denoising. Applying the limited decay filter towards a signal on the wavelet on a number of scales results in [4] while the wavelet destroys the information of obstacle phase of self-similarity in base functions, so coefficients provide information only for locally referenced information. In addition, even if the word "scale" can be defined as almost "frequency", then there is no direct method of converting the data into the appropriate frequency information on the scale.

The Stockwell Transform (called ST, and many times called as S-transform) [13, 20 ,21] is frequent frequency decomposition, which is information about the fully referenced phase of coefficients. Yes, the accumulation of a Fourier coefficient used for a preset frequency produces the strict fourier coefficients intended for the frequency; while medium size signs require a lot of time and memory because ST is very extravagant. Although this is a reform on the packed ST tribe, discrete orthonormal stockwell transform is awkward on behalf of those application which are big signs, such as auditory processing, remote sense, and remedial imaging.

DST has been used in different areas according to the direct current value of fourier transform. For e.g., they are used to analyze inner an distinctive wave packet, full of atmosphere study, description of seismic signals, the analysis of universal sea surface temperature study. It is also used in the remedial area to study creature being mind mapping , a cardiovascular study, MRI study and effect of medicines. ST become increasingly more expensive for high-dimensional data, in order to carry out decomposition in this time-frequency, an extra effective precise and computational structure is desired.

DOST is completely velvet down version of unnecessary ST[20] as the duration of low frequencies is quite high , so it is argued that low frequencies can survive lower sample rates. Therefore, DOST low frequencies sub samples Similarly, high sampling rates in high frequencies, discrete orthonormal stockwell transform has benefit of this space model with distribution of its coefficients consequently.

Till today, stockwell transform and discrete orthonormal stockwell transform were not usually used on huge images or else three-dimensional quantity record set.

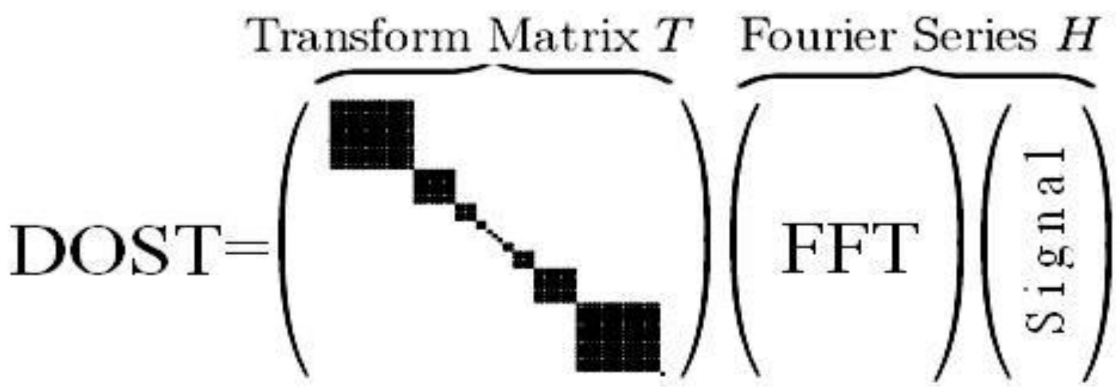


Fig 5.2 : algorithm steps for DOST

5.3 Algorithm Steps :

The proposed algorithm steps are given below :

1. Upload the standard image.
2. Divide it into 8 * 8 blocks.
3. Apply the DCT on that image and obtain the output.
4. Now the output of DCT will treated as an input for S-transform.
5. Apply the S-transform on that image and obtain the output image.
6. For the optimization of image, we apply an optimization on the output of the S-transform.
7. The resultant image will be the optimal image.

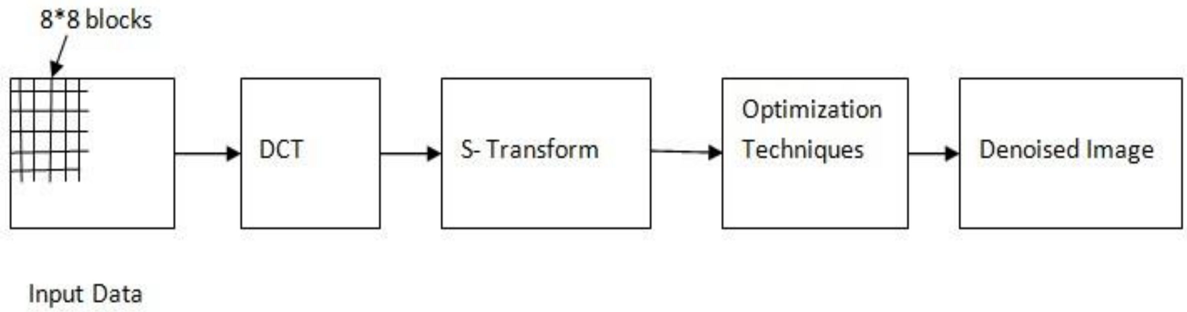


Fig 5.3 : Algorithm steps for proposed method

CHAPTER 6

RESULTS AND DISCUSSION

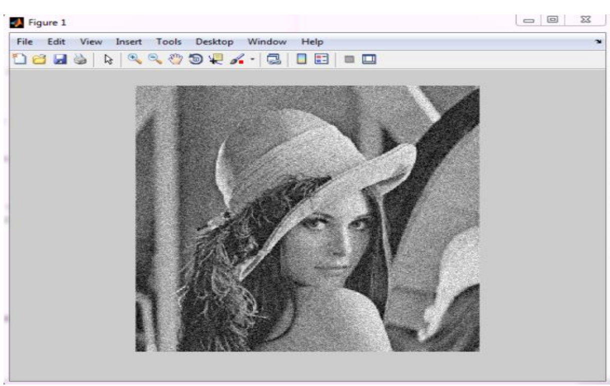
6.1 VERSION USED AND SYSTEM NECESSITY

The version of MATLAB used is R2013a and 2016b. The system requirements and specifications are mentioned in the Table 1 given below:

	REQUIREMENTS	**SPECIFICATIONS USED**
PROCESSOR	Any Intel or AMDx86 processor	Intel Core i5 M480 @ 2.67GHz
RAM	2GB	4GB
DISK SPACE	1 GB for MATLAB only, 3–4 GB for a typical installation	4-5 GB
OPERATING SYSTEM	Windows 2003, 2008,2012, XP, Vista, Windows 7, Windows 8, Windows 8.1	Windows 7 (64-Bit)

Table 6.1: MATLAB requirements and specifications

6.2 RESULTS AFTER USING MEDIAN FILTER:



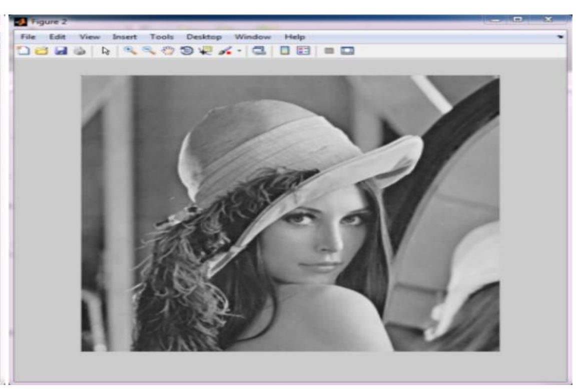


Image 6.1: Noisy image

Image 6.2: Denoised image

6.3 RESULTS AFTER USING LINEAR FILTER:

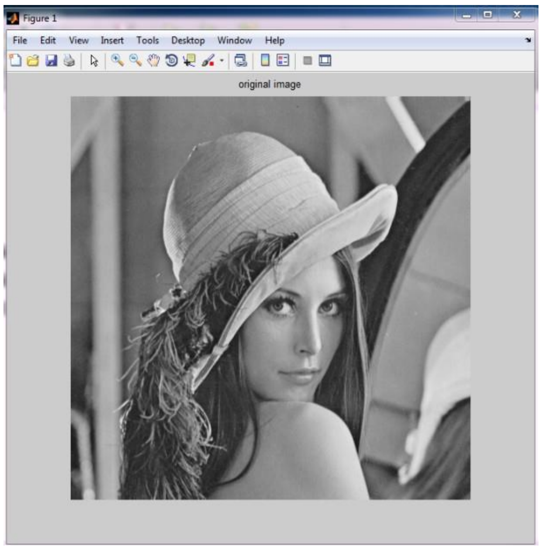


Image 6.3: Before linear filtering

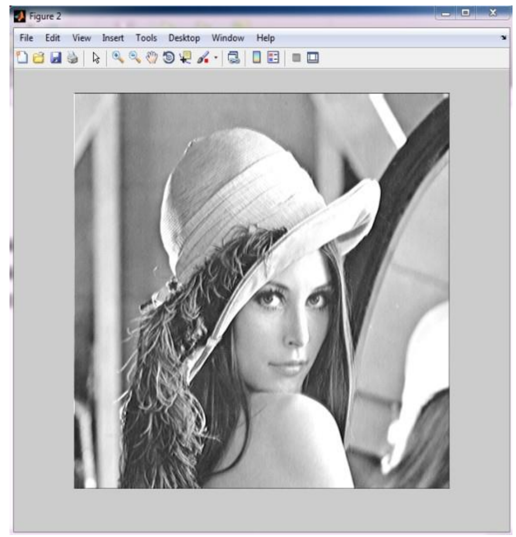


Image 6.4: After linear filtering

6.4 DISCRETE COSINE TRANSFORM:

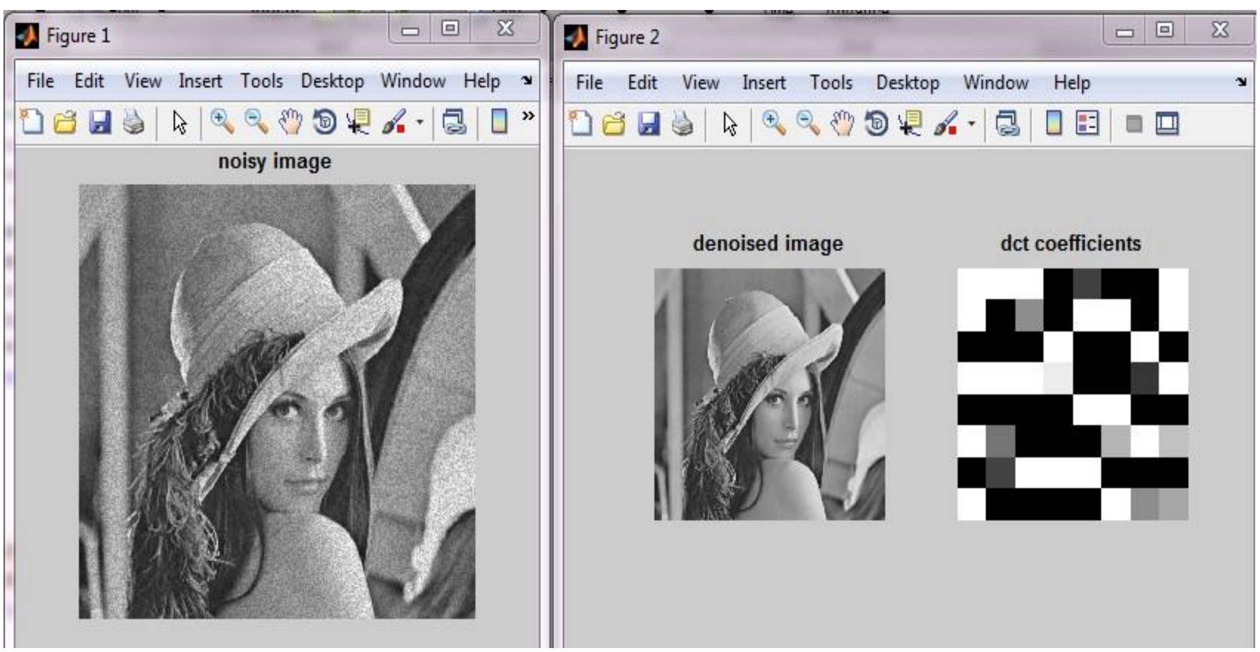


Image 6.5: Output after applying DCT on lena image

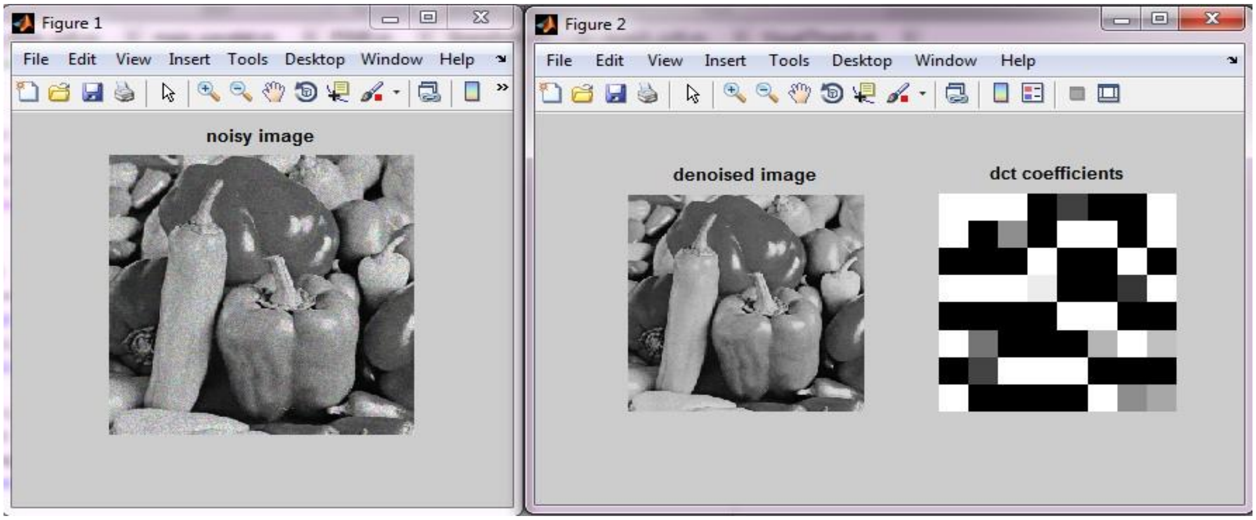


Image 6.6: Output after applying DCT on pepper image

6.5 DISCRETE WAVELET TRANSFORM:

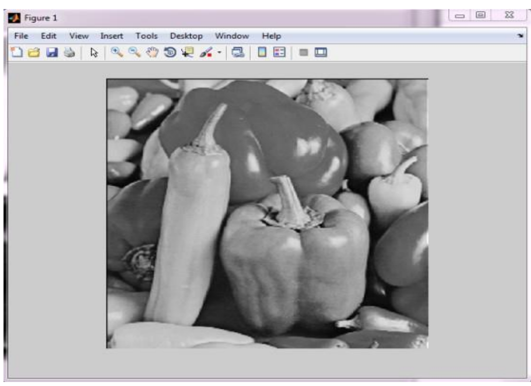


Image 6.7: original image

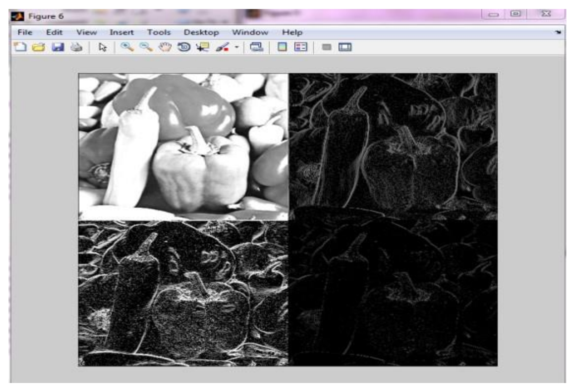


Image 6.8: after applying DWT

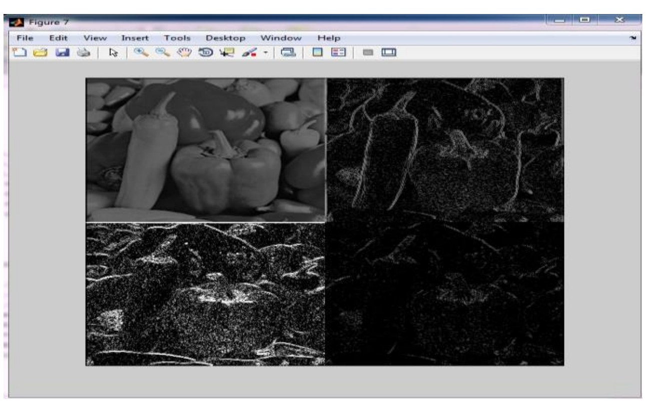


Image 6.9: after applying DWT on LL

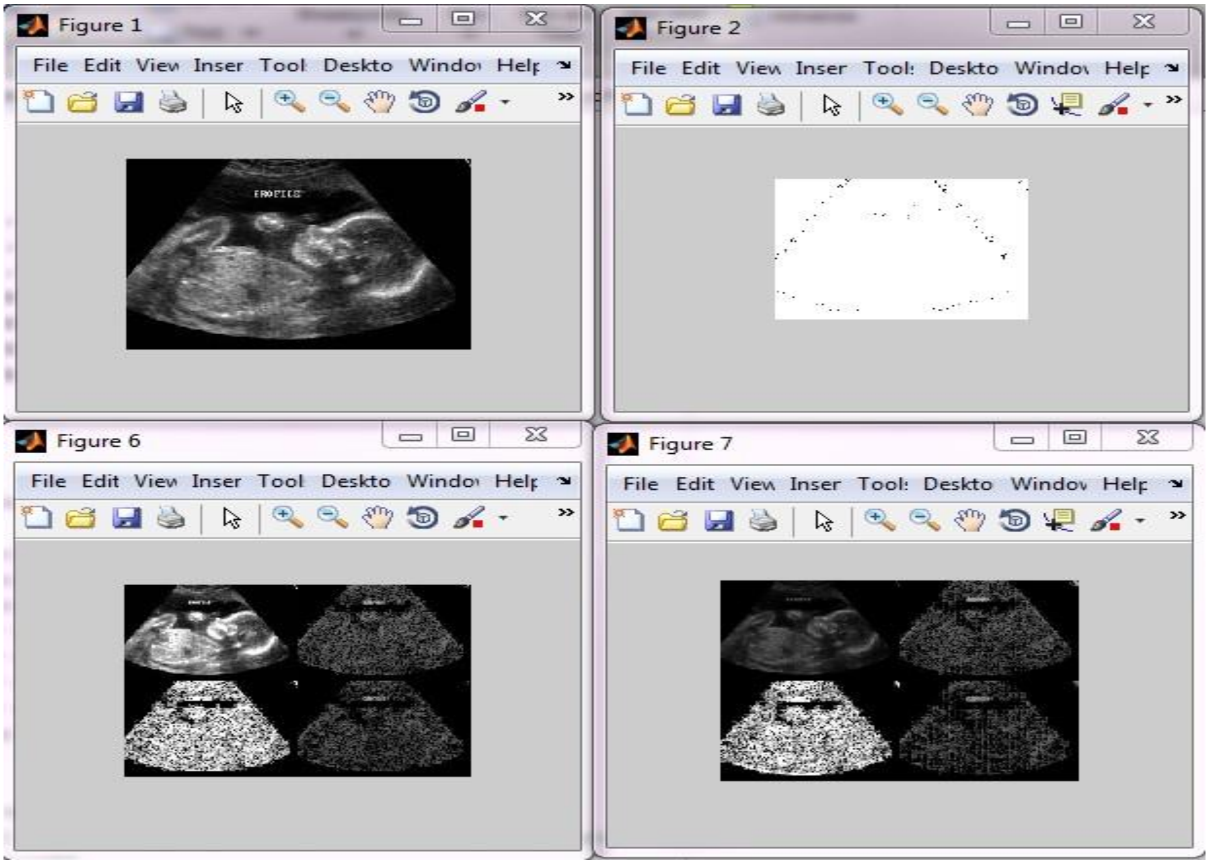


Image 6.10: after applying DWT on ultrasound image

6.6 DISCRETE STOCKWELL TRANSFORM:

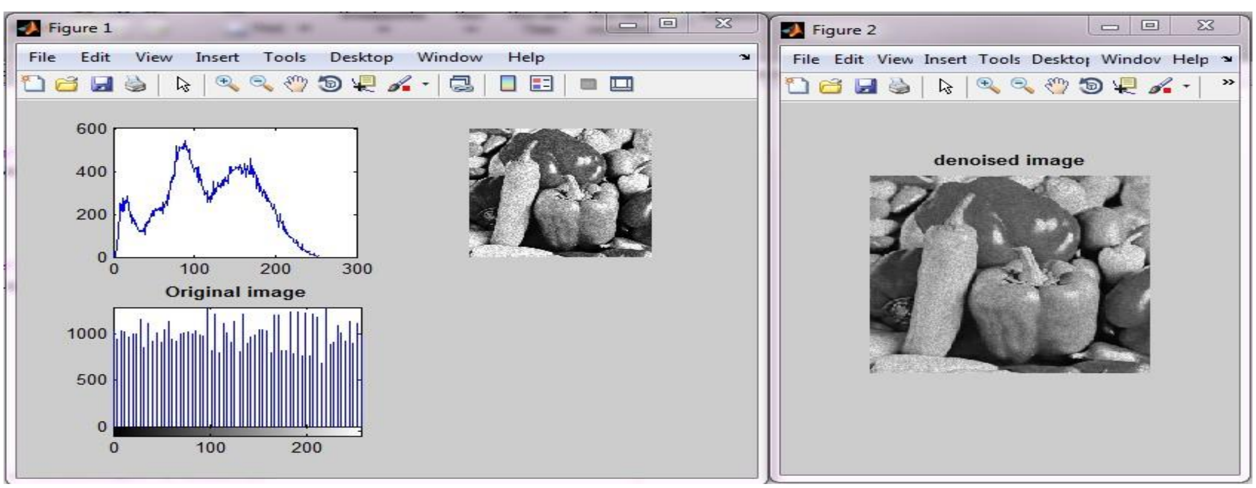


Image 6.11: after applying DST on pepper image

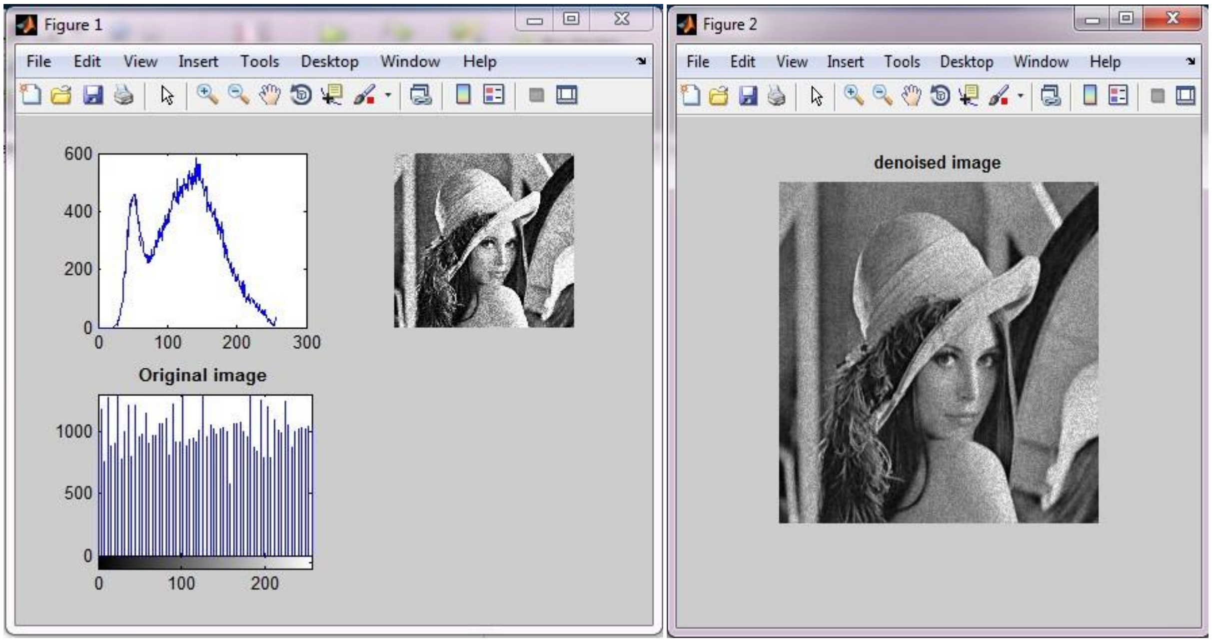


Image 6.12: after applying DST on lena image

6.7 RESULTS USING PROPOSED ALGORITHM :

Image 6.13 : initial image

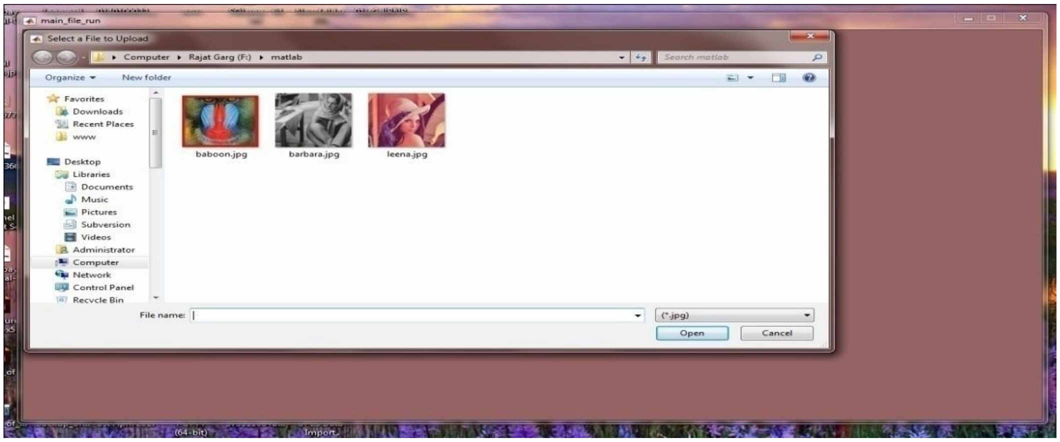


Image 6.14 : browse image to upload

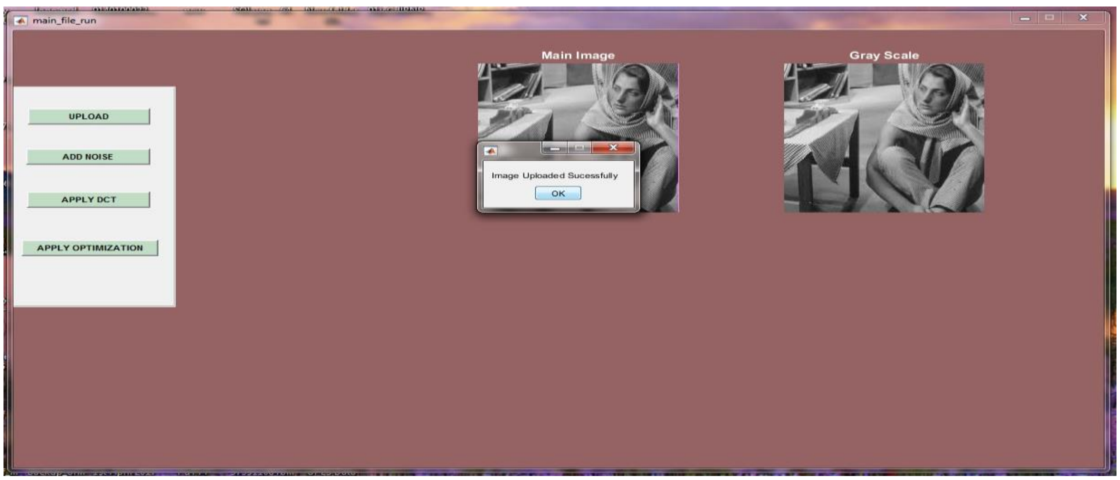


Image 6.15 : image uploaded successfully

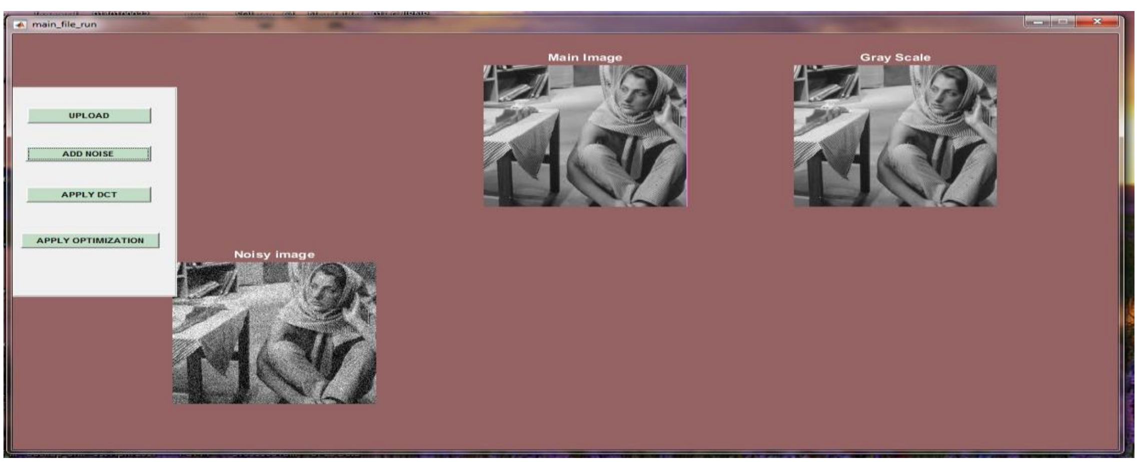


Image 6.16 : noise added in the image

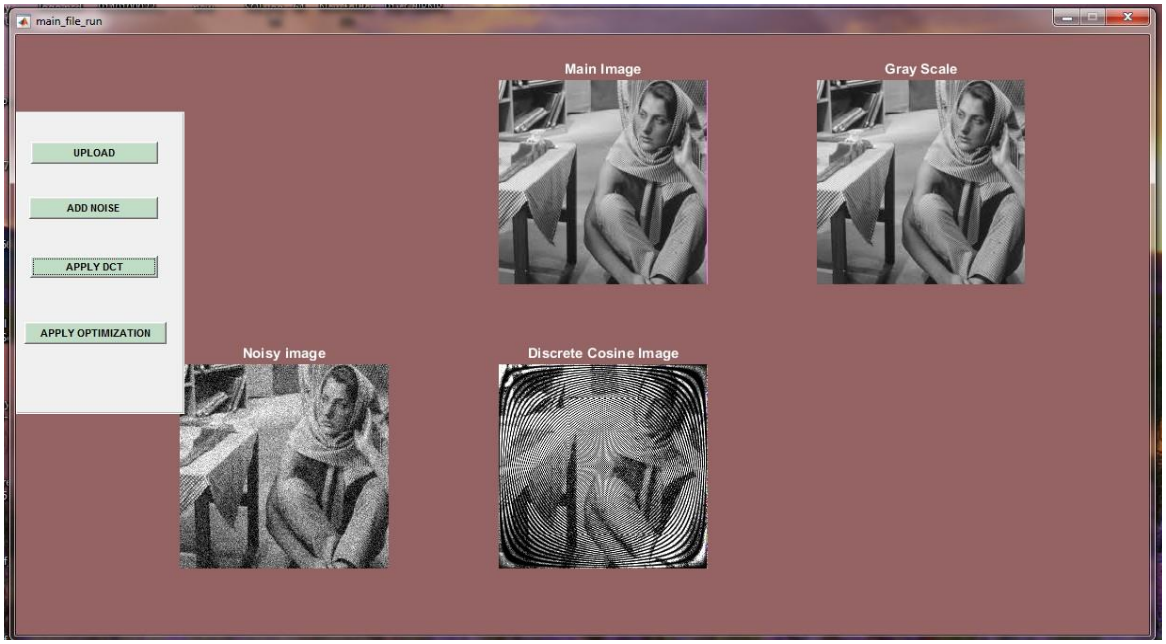


Image 6.17 : apply DCT on image

Image 6.18 : denoised image after optimization

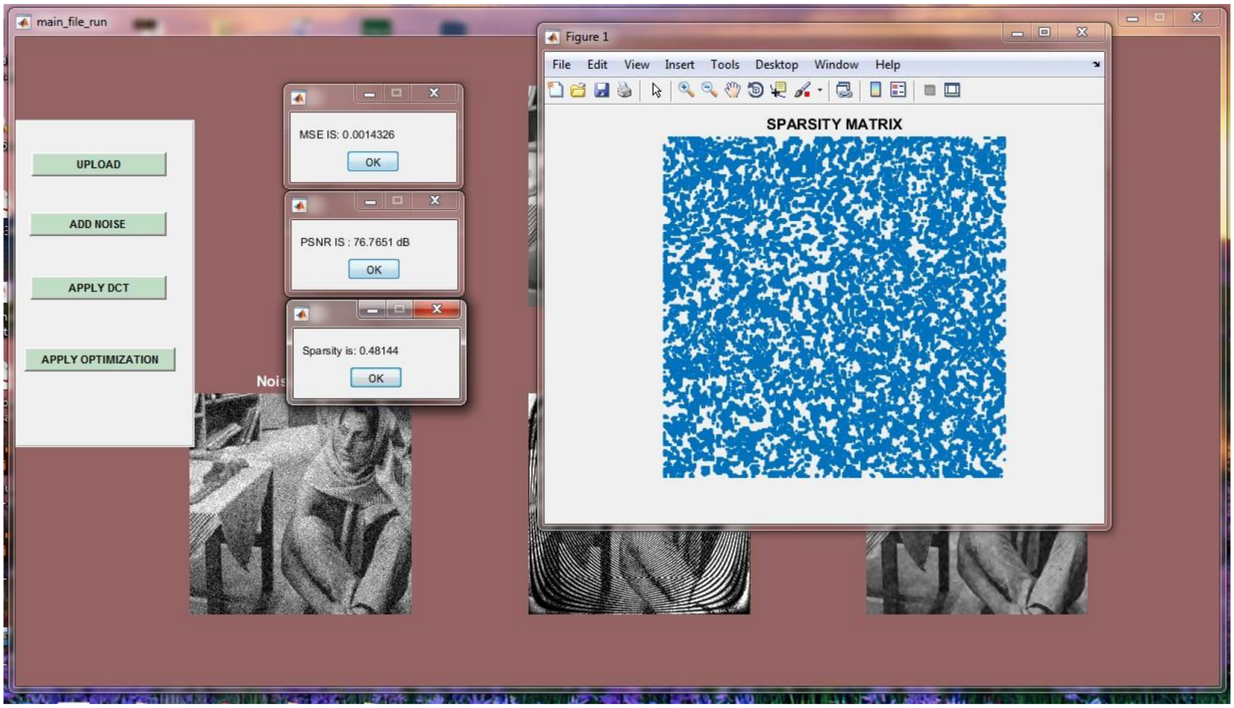


Image 6.19 : calculated values of PSNR,MSE and sparsity for Barbara image

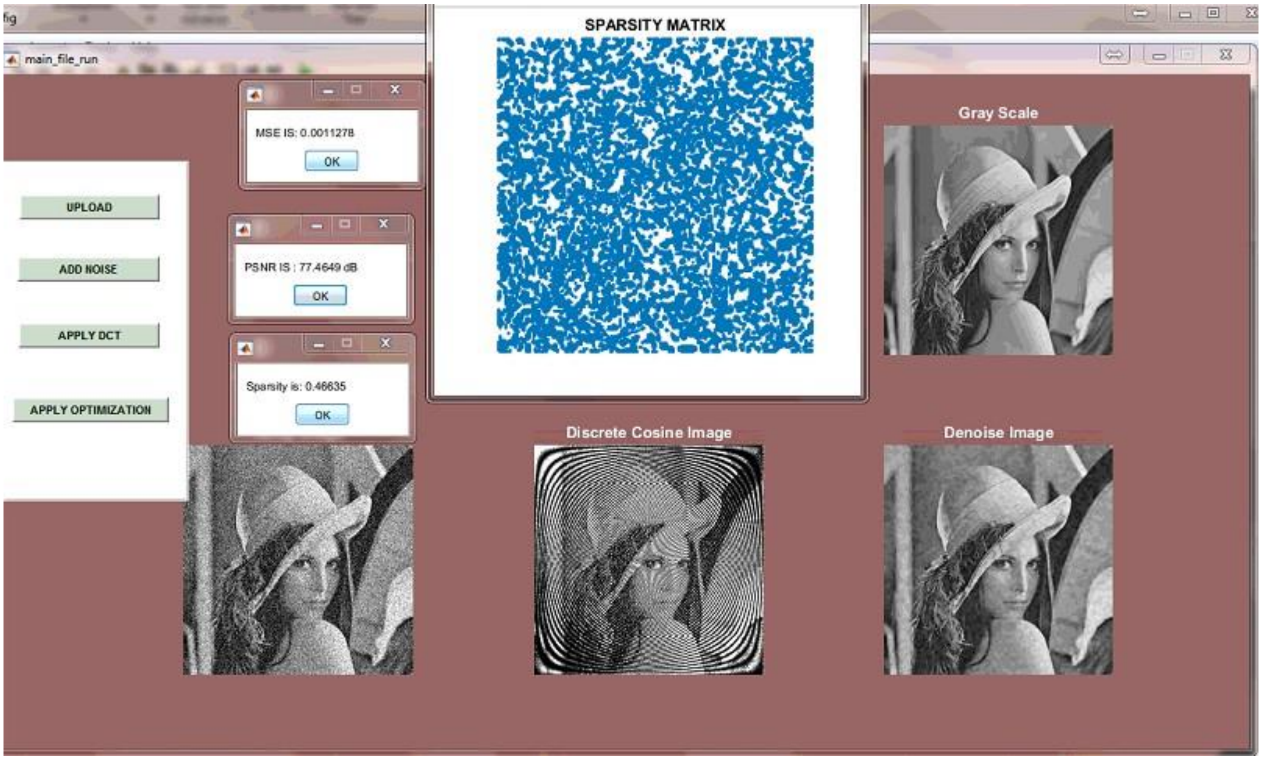


Image 6.20: Calculated values of PSNR, MSE and sparsity for lena image

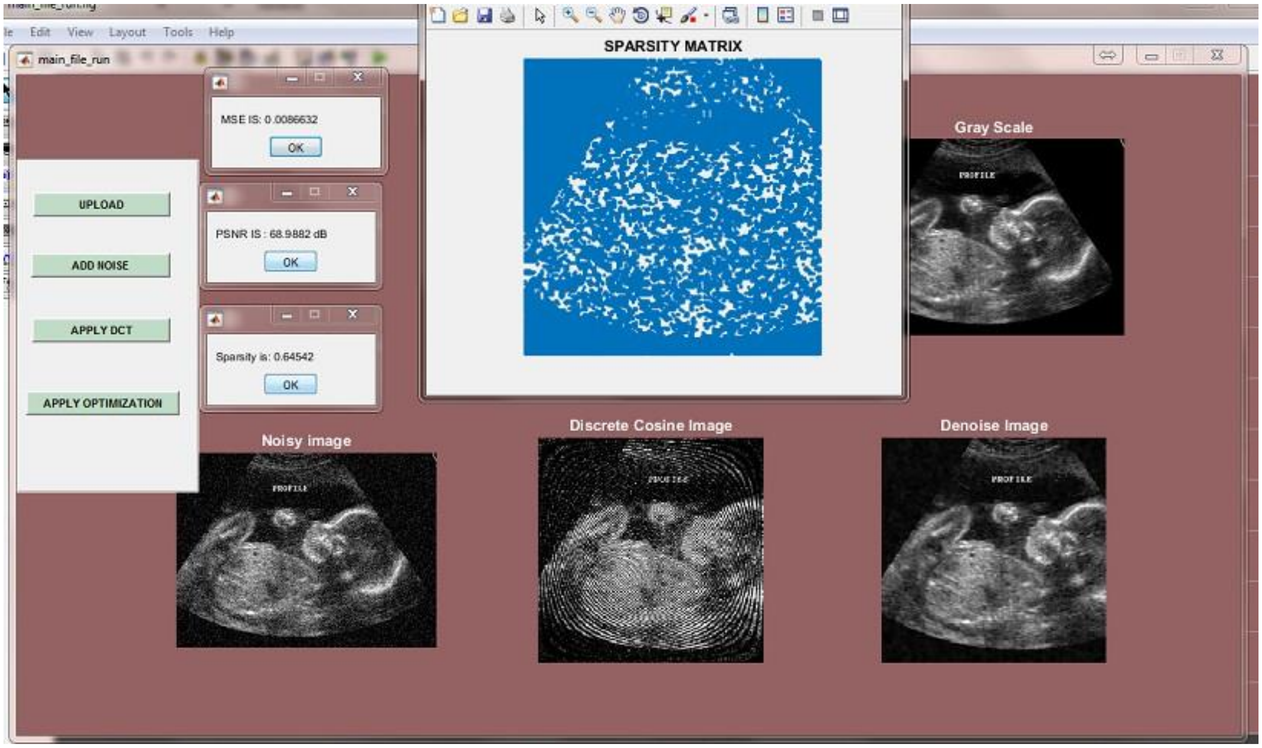


Image 6.21 : calculated values of PSNR,MSE and sparsity for ultrasound image

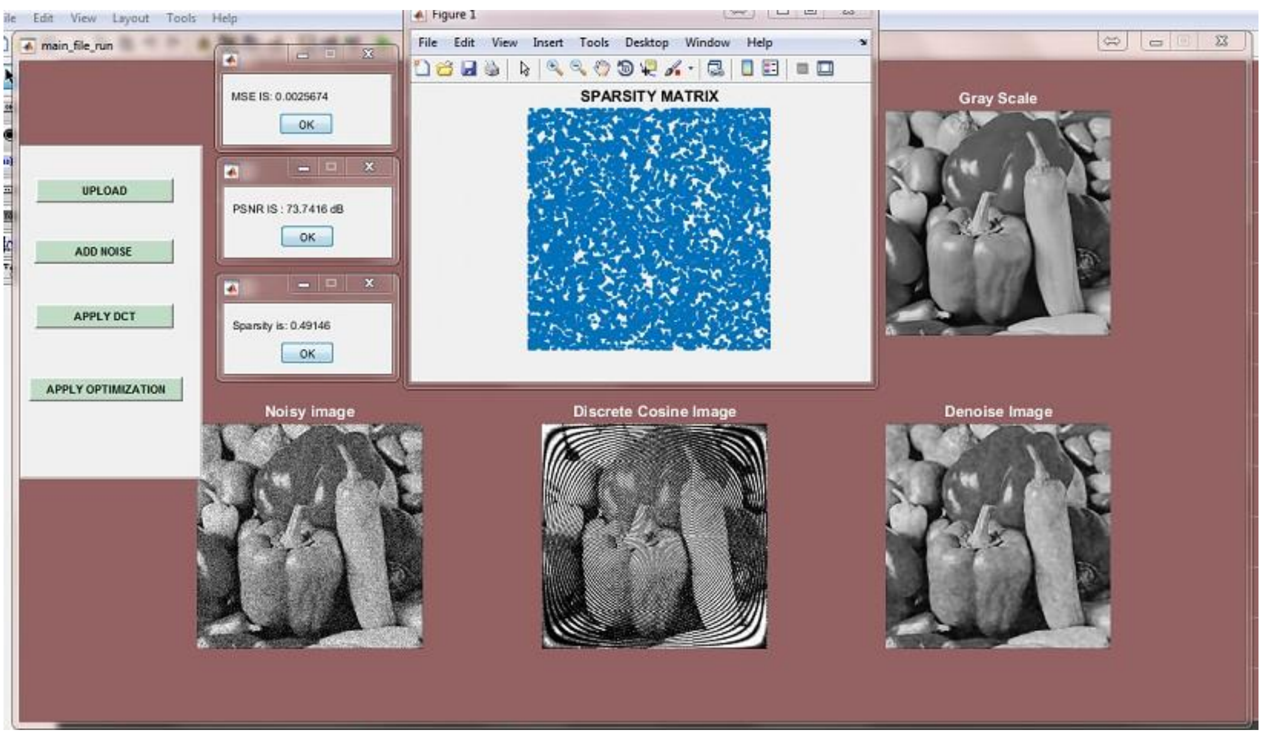


Image 6.22 : calculated values of PSNR,MSE and sparsity for peppers image

6.8 EXPERIMENTAL RESULTS:

The mean square error (MSE) is calculated as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The peak signal to noise ratio is calculated as:

$$PSNR = 10.\log_{10}(\frac{MAX_1^2}{MSE})$$

$$PSNR = 20.\log_{10}(\frac{\mathrm{MAX}_1}{\sqrt{\mathrm{MSE}}})$$

Technique	Images	PSNR of noisy image in DB	PSNR of denoised image in DB	Mean square error (MSE)
DCT	Lena	29.274	29.767	20.859
	Peppers	29.223	30.022	21.176
	Barbara	28.789	29.765	21.223
	Index	29.695	30.136	21.551
Haar wavelet	Lena	25.6812	26.9793	20.402
	Peppers	25.9041	27.0954	21.481
	Barbara	25.9325	27.0942	21.863
	Index	31.3487	32.3105	22.794
DB2 wavelet	Lena	25.3212	26.8972	20.329
	Peppers	25.7104	26.9094	20.276
	Barbara	25.5234	27.7843	20.765
	Index	31.4398	32.5391	21.121

S-transform	Lena	25.7202	27.8854	20.125
	Peppers	25.9533	27.8233	20.356
	Barbara	25.9261	27.9571	20.012
	Index	31.3114	32.8924	20.023

Table 6.2: comparison of results from different transforms

After applying proposed algorithm, results are given below :

Technique	Images	PSNR of denoised image in DB	Sparsity	Mean square error (MSE)
DCT + S-transform + optimization	Lena	77.4649	0.46635	0.0011278
	Peppers	73.7416	0.49146	0.0025674
	Barbara	76.7651	0.48144	0.0014326
	Index	68.9882	0.64542	0.0086632

Table 6.3: Results from proposed algorithm

CHAPTER 7

SOURCE CODE

7.1 Code for DCT :

```
%%%%%START%%%%%
clc;
clear all;
a = imread('peppers.jpg');
im=imnoise(a,'speckle',0.01);
imshow(im);
title('noisy image','fontweight','bold');
figure
N=8;
for i1=1:N
    for j1=1:N
         if i1-1==0
       T(i1,j1)= 1/sqrt(N);
         elseif (i1-1)>0
            x1=2*(j1-1)+1
x2=x1*(i1-1)*pi
x3=x2/(2*N)
T(i1,j1)=sqrt(2/N)*cos(x3)
         end
    end
end
T2=T'
a2= a(1:8,1:8)
a2=[162 162 162 161 162 157 163 161;162 162 162 161 162 157 163 161;162 162
162 161 162 157 163 161;162 162 162 161 162 157 163 161;162 162 162 161 162
157 163 161;164 164 158 155 161 159 159 160;160 160 163 158 160 162 159
156;159 159 155 157 158 159 156 157]
a3=a2-128
d=T*a3*T2
q=[16 11 10 16 24 40 51 61;12 12 14 19 26 58 60 55;14 13 16 24 40 57 69 56;14
17 22 29 51 87 80 62;18 22 37 56 68 109 103 77;24 35 55 64 81 104 113 92;49 64
78 87 103 121 120 101;72 92 95 98 112 100 103 99]
c = round(d./q)  h =
q.*c
m=round(T2*h*T)+128
subplot(1,2,1)
imshow(a)
title('denoised image','fontweight','bold');
subplot(1,2,2)
imshow(d)
title('dct coefficients','fontweight','bold');
e=sum(sum((a2-m).^2))
e1=e/64;
f=255
f1=f/e1
f2=log10(f1)
```

```
psnr=20.*f2
%%end%%
```

7.2 Code for DWT :

```
%%discrete wavelet transform (haar wavelet)%%
clear all;
close all;
x = imread('index.jpg');
figure;
imshow(x);
[ xar,xhr,xvr,xdr] = dwt2(x(:,:,1),'haar'); [
xag,xhg,xvg,xdg] = dwt2(x(:,:,2),'haar'); [
xab,xhb,xvb,xdb] = dwt2(x(:,:,3),'haar');
xa(:,:,1) = xar; xa(:,:,2) = xag; xa(:,:,3) = xab;
xh(:,:,1) = xhr; xh(:,:,2) = xhg; xh(:,:,3) = xhb;
xv(:,:,1) = xvr; xv(:,:,2) = xvg; xv(:,:,3) = xvb;
xd(:,:,1) = xdr; xd(:,:,2) = xdg; xd(:,:,3) = xdb;
figure; imshow (xa);
figure; imshow (xh);
figure; imshow (xv);
figure; imshow (xd);
x1 = [xa*0.003 log10(xv)*0.3; log(xh)*0.3 log10(xd)*0.3];
figure; imshow(x1);
[ xaar,xhhr,xvvr,xddr] = dwt2(x(:,:,1),'db2'); [
xaag,xhhg,xvvg,xddg] = dwt2(x(:,:,2),'db2'); [
xaab,xhhb,xvvb,xddb] = dwt2(x(:,:,3),'db2');
xaa(:,:,1) = xaar; xaa(:,:,2) = xaag; xaa(:,:,3) = xaab;
xhh(:,:,1) = xhhr; xhh(:,:,2) = xhhg; xhh(:,:,3) = xhhb;
xvv(:,:,1) = xvvr; xvv(:,:,2) = xvvg; xvv(:,:,3) = xvvb;
xdd(:,:,1) = xddr; xdd(:,:,2) = xddg; xdd(:,:,3) = xddb;
x11 = [xaa*0.001 log10(xvv)*0.3; log(xhh)*0.3 log10(xdd)*0.3];
figure;
imshow(x11);
%%%end%%%
```

Code for DWT :

```
%% discrete wavelet transform using threshold values%%
 clc
clear
close all
im=imread('index.jpg');
im=imresize(im,[256 256]);
im=imnoise(im,'salt & pepper',0.01);
imshow(im)
title('Original image','fontweight','bold')
if size(im,3)==3
    im=rgb2gray(im);
end
level=1;
[Re_Image,psnr] = Visushrink(im,level);
figure,
```

```
imshow(Re_Image)
title('De-Noised Image')
```

Code for PSNR :

```
function psnr= PSNR(im1,im2)
[row,col]=size(im1);
[row1,col1]=size(im2);
if row~=row1 && col~=col1
    error('Dimension of both the images must be same')
end N=0;
c1=class(im1);
c2=class(im2);
if strcmpi(c1,'uint8')
    im1=double(im1);
end
if strcmpi(c2,'uint8')
    im2=double(im2);
end
for i=1:row
    for j=1:col
        N=N+((im1(i,j)-im2(i,j))^2);
    end
end
N=N/(row*col);
psnr=10*log10(255*255/N);
```

Code for threshold values :

```
function st=thresh_soft(X,T)
    index1=find(abs(X)<=T);
    index2=find(abs(X)>T);
    X(index1)=0;
    X(index2)=sign(X(index2)).*(abs(X(index2))-T);
    st=X;
```

Code for visual threshold :

```
function [th]=VisualThresh(im)
    if size(im,3)==3
        im=rgb2gray(im);
    end
    [row,col]=size(im);
    N=row*col;
    th=sqrt(2*log(N));
```

Code for visushrink :

```
function [Re_Image,psnr] = Visushrink(im,level)
if level==1
    [cA,cH,cV,cD] = dwt2(im,'haar');
    th1 = VisualThresh(cD);
    st_cH = thresh_soft(cH,th1);
    st_cV = thresh_soft(cV,th1);
    st_cD = thresh_soft(cD,th1);
    re_im = idwt2(cA,st_cH,st_cV,st_cD,'haar');
elseif level==2
    [cA,cH,cV,cD] = dwt2(im,'haar');
    th1 = VisualThresh(cD);
    st_cH = thresh_soft(cH,th1);
    st_cV = thresh_soft(cV,th1);
    st_cD = thresh_soft(cD,th1);
    [cA1,cH1,cV1,cD1] = dwt2(cA,'haar');
    th2=VisualThresh(cD1);
    st_cH1=thresh_soft(cH1,th2);
    st_cV1=thresh_soft(cV1,th2);
    st_cD1=thresh_soft(cD1,th2);
    re_im2=idwt2(cA1,st_CH1,st_CV1,st_CD1,'haar');
    re_im = idwt2(re_im2,st_cH,st_cV,st_cD,'haar');
end
    psnr=PSNR(im,re_im);
    Re_Image=uint8(re_im);
```

7.3 Code for S-Transform :

```
clc clear
close all
im=imread('peppers.jpg');
im=imresize(im,[256 256]);
if size(im,3)==3
    im=rgb2gray(im);
end im_orig=im;
im=imnoise(im,'speckle',0.01);
psnr_noisy=PSNR(im_orig,im);
imshow(im);
h= imhist(im);
subplot (2,2,1);
plot (h);
im2 = histeq(im);
subplot (2,2,2);
imshow (im2);
subplot (2,2,3);
imhist (im2);
title('Original image','fontweight','bold');
im=double(im);
DOST=Stransform.dost2(im);
th1 = VisualThresh(im);
th2 = VisualThresh(DOST);
```

```
magDOST=abs(DOST);
index1=magDOST<th2;
index2=magDOST>=th2;
magDOST(index1)=0;
magDOST(index2)=((magDOST(index2)-th2)./magDOST(index2)).*DOST(index2);
re_im=Stransform.idost2(magDOST);
re_im1=abs(re_im);
figure,imshow(re_im1,[]);
title('denoised  image','fontweight','bold');
psnr_denoisy=PSNR(im_orig,re_im1);
str=['PSNR  of  noisy  image=',num2str(psnr_noisy)];
str1=['PSNR  of  de-noised  image=',num2str(psnr_denoisy)];
disp(str)
disp(str1)
```

Code for PSNR :

```
function  psnr=  PSNR(im1,im2)
[row,col]=size(im1);
[row1,col1]=size(im2);
if  row~=row1  &&  col~=col1
    error('Dimension  of  both  the  images  must  be  same')
end  N=0;
c1=class(im1);
c2=class(im2);
if  strcmpi(c1,'uint8')
    im1=double(im1);
end
if  strcmpi(c2,'uint8')
    im2=double(im2);
end
for  i=1:row
    for  j=1:col
        N=N+((im1(i,j)-im2(i,j))^2);
    end
end
N=N/(row*col);
psnr=10*log10(255*255/N);
```

Code for threshold values :

```
function  st=thresh_soft(X,T)
    index1=find(abs(X)<=T);
    index2=find(abs(X)>T);
    X(index1)=0;
    X(index2)=sign(X(index2)).*(abs(X(index2))-T);
    st=X;
```

Code for visual threshold :

```
function  [th]=VisualThresh(im)
```

```
    if size(im,3)==3
        im=rgb2gray(im);
    end
    [row,col]=size(im);
    N=row*col;
    th=sqrt(2*log(N));
```

Code for visushrink :

```
function [Re_Image,psnr] = Visushrink(im,level)
if level==1
    [cA,cH,cV,cD] = dwt2(im,'haar');
    th1 = VisualThresh(cD);
    st_cH = thresh_soft(cH,th1);
    st_cV = thresh_soft(cV,th1);
    st_cD = thresh_soft(cD,th1);
    re_im = idwt2(cA,st_cH,st_cV,st_cD,'haar');
elseif level==2
    [cA,cH,cV,cD] = dwt2(im,'haar');
    th1 = VisualThresh(cD);
    st_cH = thresh_soft(cH,th1);
    st_cV = thresh_soft(cV,th1);
    st_cD = thresh_soft(cD,th1);
    [cA1,cH1,cV1,cD1] = dwt2(cA,'haar');
    th2=VisualThresh(cD1);
    st_cH1=thresh_soft(cH1,th2);
    st_cV1=thresh_soft(cV1,th2);
    st_cD1=thresh_soft(cD1,th2);
    re_im2=idwt2(cA1,st_CH1,st_CV1,st_CD1,'haar');
    re_im = idwt2(re_im2,st_cH,st_cV,st_cD,'haar');
end
    psnr=PSNR(im,re_im);
    Re_Image=uint8(re_im);
```

CONCLUSION

A lot of researchers made many extensive researches in this field, still, we need to establish a denoising algorithm which can successfully discover and eliminate noise to much greater extent. we can conclude that among all the filters median filters gives ideal results. The image acquired from the median filter has no noise present in it and is close to the high quality image. The clarity of the image in non linear filtering is high in the comparison to linear filtering. We can conclude from the results in above table, we can state that S-transform provides us better PSNR values than the other transforms. We have proposed a new algorithm in which there are better PSNR , MSE and sparsity values. We have merged discrete cosine transform and the S-transform. After combining these two algorithms we have applied the optimization techniques.

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