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ANALYSIS OF DIFFERENT RESTORATION TECHNIQUES TO REDUCE DIFFERENT TYPES OF NOISE & BLUR IN CAMERA IMAGES

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***Abstract*— The field of digital image processing deals not only with the extraction of features, analysis of images and restoration of images but also with the process of enhancement, filtering and restoration of images. Image restoration is one of the basic steps of processing that deals with making certain improvements in a digital image based on some predefined criteria .The prime objective of restoration is to build or reconstruct an image that has been degraded based on some prior knowledge regarding the phenomena of degradation of images .The process of restoration is objective in nature that is; it aims at a specific goal like removal of blur & noise in an image by means of a deburring function. Image restoration is process of recovering the original image by removing noise and blur from image. Image blur is difficult to avoid in many situations like photography, to remove motion blur caused by camera shake, radar imaging to remove the effect of image system response, etc. Image noise is unwanted signal which comes in image from sensor such as thermal or electrical signal and Environmental condition such as rain, snow etc. Researchers have proposed many methods in this regard and in this paper we will examine and discuss different noise and blur models and restoration method.**

This Paper generally designed to comparatively the performance of different image restoration technique. The images are degraded by numerous parameters like noises in the environment or blurring of the image during image gaining or during processing of the image. In order to improve the quality of the image so that the required objects can be easily available from the sensed images. It improves the objectivity of the image and removes the noise and blurry content in the image.

***Index Terms*— Image Processing, Image Restoration, Noise, Blur, SWT, NSCT, DWT, CT.**

I. INTRODUCTION

Acquisition, storing, and processing of digital images are still becoming more important applications in our daily life. De-noising, de-blurring, smoothing, and simplification are central problems in digital image processing. All three of them aim at increasing the eminence of an image either to a human observer or as pre-processing step for a computer vision system. Image restoration is the major portion of digital image processing which includes research based on algorithm and custom objective oriented image Processing. It deals with reduction of degradations that are seen in the image obtained. Degradation occurs due to blurring and noise that is incorporated in the image by various sources. Noise is interrupted in the broadcast medium due to a noisy nature of the channel, produce errors during transmission and quantization of the data for digital storage [1-2]. Further, it is a matter of great concern, if the noisy and blur image data has to send over the network for transmission using cryptography. Therefore, it is required to restore the noisy and blur image before actually, it could be used for further image processing tasks [3].

Image restoration is one of the required tasks in image processing for better analysis and vision. There are several noises which can degrade the quality of images. There are various types of noise models including multiplicative and additive noises. These are speckle noise, Gaussian noise, Poisson noise, salt and pepper noise, etc. Gaussian noise is evenly distributed over the signal. Salt & pepper noise is an impulse type of noise. This introduces error in data transmission. There are many types of image restoration techniques which are used for all type of noisy and blured images. These are Linear smoothing, Median filtering, denoising using local statistics, different variant of wavelet transform and contour let transform based methods.

The various quality performance measuring indices, such as Correlation Coefficient (CC), Mean-Square-Error (MSE) and Signal-to-Noise Ratio (SNR), Peak-Signal-to-Noise Ratio (PSNR), between the original and the restored image. Image Filters play an vital role in the image de-nosing and de-blurring process. The basic concept behind image de-nosing and de-blurring using linear filters is digital convolution, along with the concept of moving window. In some cases this filtering technique fails in the image restoration process. Due to this reason, a new technique was introduced which is referred as Wavelet Transform.

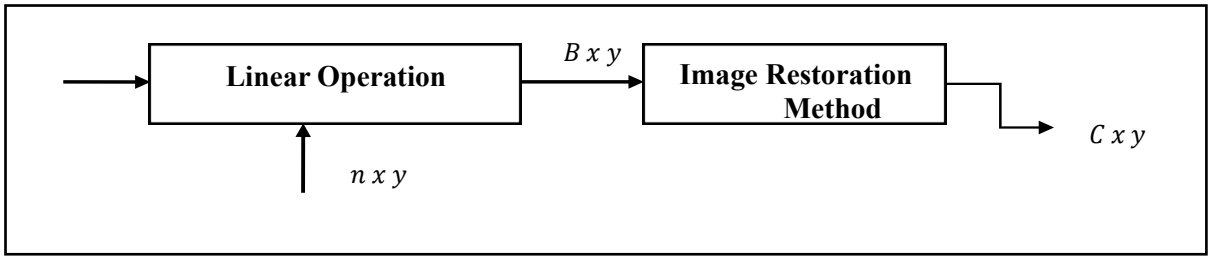

Figure 1.1- Concept of Image Restoration [2]

OBJECTIVES OF THE WORK

Based on results of a thorough study on image restoration techniques. The following are the objectives of this study.

a) Analysis and implementation of image restoration techniques in multi-resolution based domain using a defined thresholding.
b) Reduce different types of noise and blur in camera images using different restoration techniques.
c) To evaluate the performance of different restoration techniques in terms of different evaluation metrics.
d) To apply the image restoration techniques for the given data sets by programming in MATLAB environment.
e) The image restoration techniques will be tested using different image sets. The generated results will then be evaluated both visually and quantitatively along with discussions on the properties of the restoration techniques.

II. LITERATURE REVIEW

Changet al., 2000, proposed Wiener and Median filtering algorithms to de-noise image with different types of noise, such as, Gaussian noise and Speckle noise, Salt & Pepper noise that are either introduced in the image during capturing or incorporated into the image during transmission. Analysis of result shows that the performance of Wiener filter is better than Median filter in case of Speckle and Gaussian noisy image, while the Median filter outperforms the Wiener filter in case of Salt & Pepper noisy image.

Chenet al., 2003, describe and implemented different image de-noising techniques and their performance comparatively assessed. Analysis of results showed that the wavelet based de-nosing technique has proved to be good for de-noising of natural images because of their sparseness energy compression, and alliance properties, when compared to other image de- noising techniques.

Portillaet al., 2004, presented to investigate the suitability and effectiveness of different variable window size of Wavelet bases and the size of different neighborhood, along with different threshold techniques. Analysis of result shows that wavelet transform based image de- noising methods is best in terms of PSNR, retaining spectral and spatial quality, when, compared with the three other approaches examined.

Tsakanikas et al., 2007, presented the concept of Contourlet Transform for image de- noising of 2D gels and do a comparative analysis. Analysis of result shows that the Contourlet Transform based image de-noising algorithms exhibits good results in terms of PSNR, preservation of edges and colour radiometry, when compared to Wavelet Tansform based image de-noising technique.

Mohideen et al., 2008, presented a comparative study of transform based image de- noising techniues in terms of differentwavelet bases. Analysis of result shows that the coiflet wavelet function exhibits good results in terms of preservation of edges, lines and colour radiometry, when compared to modified Neigh shrink, Weiner filter, Neigh and Vishushrink.

Taludar et al., 2012, presented a latest trends, thorough analysis, usefulness and implementation of various image denoising techniques. Analysis of result shows that the Discrete Wavelet Transform based de-noising technique exhibits good results in terms of preservation of edges, lines and colour radiometry and required less computation time to excute, when compared to spatial, Transform based and multi-resolution based image de-noising techniques.

III. IMAGE RESTORATION TECHNIQUES

Noise in image is introduced by variations in the pixel values having variable intensity information. Noise and blur is a progression which degrades the quality of the acquired image and Noise and blur can be inserted and incorporated in images by various ways.

A. TYPES OF NOISES IN IMAGE

During image transmission, digitization process, errors in memory locations and acquirement of image through camera, are various phenomenon during through which different types of noise, such as Salt & Pepper noise, Poisson noise, Speckle noise and Gaussian noise, can be easily inserted, mixed, incorporated and added to an image, causes introduction of artifacts..

The image can also become noisy during transmission of the image in the form of digital signals. The types of noises are:

i. Gaussian noise
ii. Salt & Pepper noise
iii. Poisson noise iv. Speckle noise

B. TYPES OF BLURS IN IMAGES

An image is made up of digital data by inputting it and the output of this digital data is an image. An important problem in image processing is its blurring problem which degrades its performance and quality. Gaussian function is used firstly to

degrade the image quality and blurring an image because it is a low pass filter. Modern imaging sciences, such as consumer photography, astronomical imaging, medical imaging, and microscopy, have been well developed in recent years and a large number of progressive techniques have emerged. These developments have enabled the acquisition of images that are of both higher speed and higher resolution (also referred to as high definition). However, intrinsic or extrinsic factors behind such fast and high-resolution techniques which may lead to the deformation in the quality of the acquired image, of which blur is one example.

Further, from other view point, image blur may be sometimes intentional in images, however, blur in the image results in degradation in the image quality i.e., blur would detoriates and corrupts the minute and important information present in the image. For example, a fast moving car captured by a surveillance system might exhibit significant blurriness in the video original image, leading to difficulty in the licenseplate recognition system.

C. INITIAL INVESTIGATION OF IMAGE RESTORATION TECHNIQUES

There are various types of image restoration algorithms. They can be broadly classified into two classes:

i. Spatial Domain Based Image Restoration Technqiues.
ii. Transform Domain Based Image Restoration Technqiues.

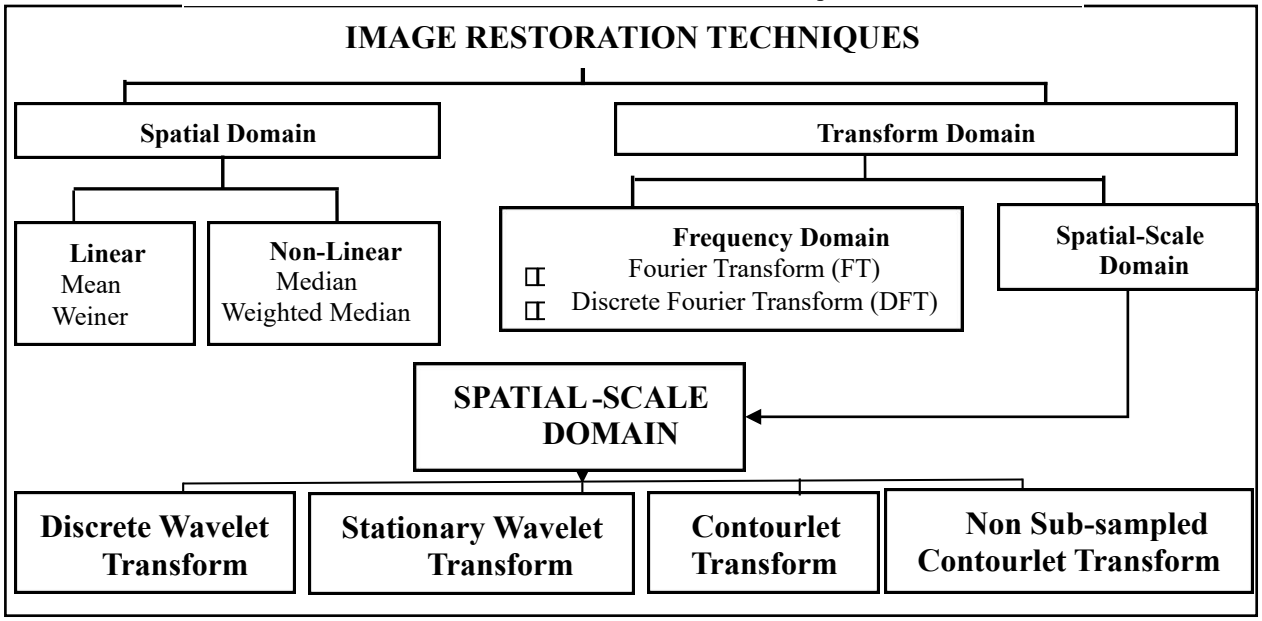

Figure 3.1 _ Classification of Image Restoration Techniques

In spatial domain filtering refers to filtering in the spatial domain, while, transform domain filtering refers to filtering in the transform domain. Further, Contourlet Transform and Wavelet Transforms based image restoration techniques falls into transform domain filtering. Moreover, spatial domain filtering can be further divided on the basis of the type of filter used:

i. Linear Filters
ii. Non-Linear Filters

D. IMAGE DE-NOISINGUSING MULTI-RESOLUTION BASED TECHNIQUES

Over the years, a multi-resolution based image de-noising techniques have received a lot of attention, since they preserve the spectral and spatial fidelity in the de-noised images. Further, it is more convenient in terms of information representation, analysis and interpretation. Many variations of the multi-resolution domain based de-noising techniques exist, such as Non Sub-sampled Contourlet Transform (NSCT), Stationary Wavelet Transform (SWT), Curvelet Transform (CVT), Contourlet Transform (CT) and Discrete Wavelet Transform (DWT). The next subsections give a descriptive overview and methodology of multi-resolution based image denoising techniques which are selected for the implementation purpose.

1) Image De-noising using Discrete Wavelet Transform (DWT)

Before coming to Discrete Wavelet Transform, first of all, it is worthwhile to discuss about Fourier Transform (FT), was first discovered by Jean Baptiste Joseph Fourier in 1822.

According to Fourier, it can be assumed that any periodical signal can be expressed as a sum of cosine and sine of different frequencies (Gonzales and Woods, 2003). FT can be used to converts a signal from a time domain to frequency domain (Polikar, 1999). The shortcoming associated with FT is that it does not provide the information about the time at which the particular frequency occurred. To overcome this limitation, Discrete Wavelet Transform (DWT) was introduced.

2) Image De-noising Using Stationary Wavelet Transform (SWT)

Discrete Wavelet Transform being shift-variant transform results in introduction of false information in the processed image.

In order to resolve the problem of shift-variance associated with DWT, SWT based de- noising technique has been introduced (Holschneider and Tchamitchian, 1990; Starck and Murtagh, 1994).In SWT, the filter is up-sampled by adding zeros between the coefficients, thereby excluding the downsampling step. In SWT, filter bank have been used for the decomposition of image, which in turn produces an approximation image and a detailed image, also called the wavelet plane. A wavelet plane contains the horizontal, vertical and diagonal information between and resolution. Further, the approximation image consist of equal number of rows and columns as the original image. This is due to the fact that the filters at each stage are up-sampled by adding zeros between the coefficients, which makes the size of the image equal (González-Audícanaet al., 2005; Pradnya and Sachin, 2013).The de-noising procedure followed by DWT technique has been explained in the section 3.4.3.

3) Image De-noising Using Non Sub-sampled Contourlet Transform (NSCT)

The problem associated with SWT is that it has limited directionality. The impact of this limited directionality is that it cannot capture curves, closed cotours and edges of images well. Further, both DWT and SWT based de-noising techniques perform well only at representing linear edges and point singularities. In order to solve the problem of closed contours and curved edges, Candes and Donoho, 2000, proposed the concept of Curvelet Transform (CVT). CVT provides the efficient and powerful platform to detect and capture the details of high dimensional data for better interpretation.

Further, CVT suffers with the problem of continous domain, followed by the discretization of images or signals of interest. Do and Vetterli, (2005) presented a effective way to deal with this problem. He proposed a flexible localised, multi-resolution and multi- directionaly image expansion using contour features, named, Contourlet Transform. However, the CT suffers with the problem of shift-variance, due to involvement of down-sampling and up- sampling, which in turn results in ringing artifacts (Shah et al., 2007; ALEjailyet al., 2008).

The general de-noising procedure followed by DWT, SWT and NSCT techniques can be recapitulate as follows (Yang and Jiao, 2008; Uplaet al., 2013) techniques can be summarized as follows (Fig. 3.3):

i. Perform a DWT/SWT/NSCT on each source images, one by one, to get their corresponding coefficients. ii. Obtain coefficients form the different source images are combined using defined thresholding rule, to get the de-noised coefficients.

iii. Apply Inverse DWT/SWT/NSCT technique reconstruction with new de-noised coefficient to obtain de-noised image.

It may be noted that each multi-resolution based techniques (DWT, SWT and NSCT) have its exclusive mathematical

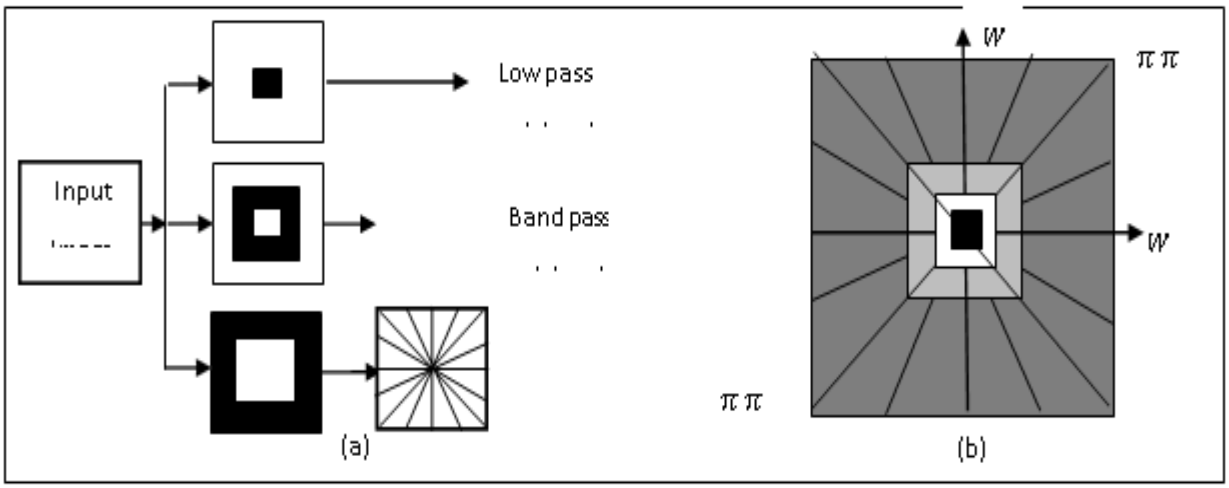

Fig: 3.2 Two level NSCT decomposition (a) NSFB structure that implements the NSCT (b) the corresponding frequency partition

properties, which leads to a unique and different image decomposition procedure of an image.

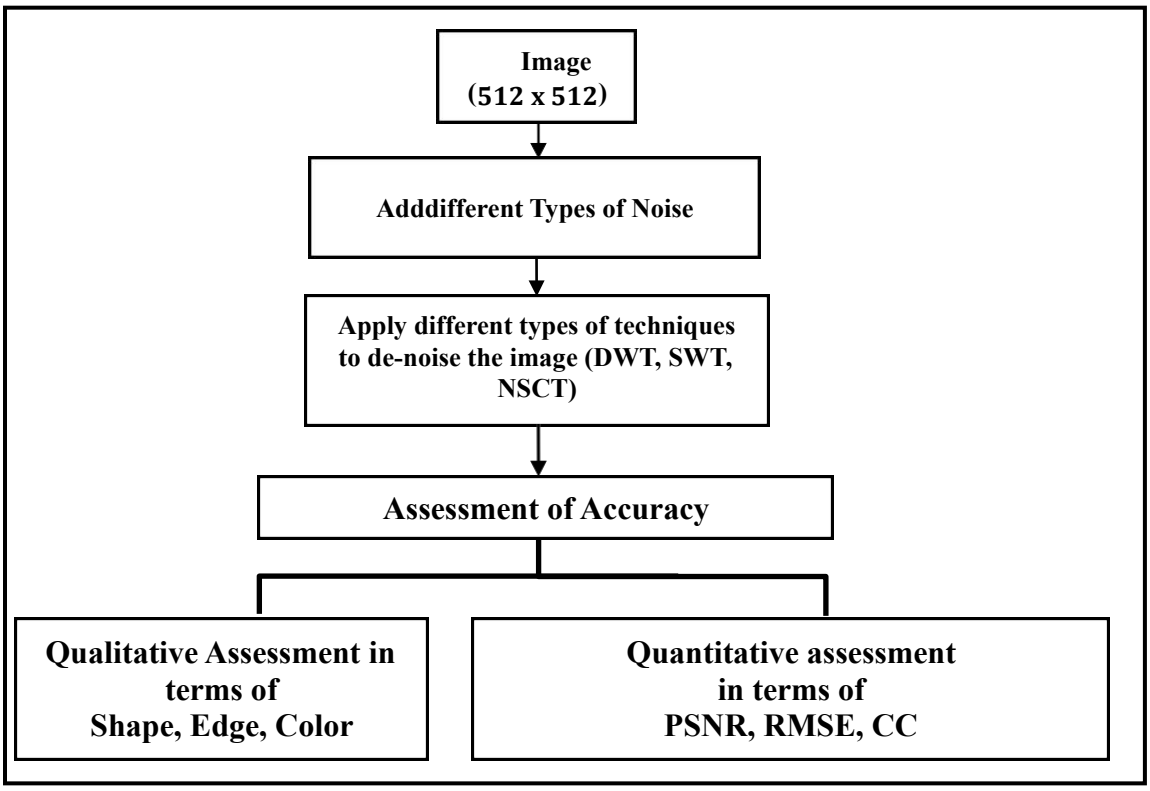

Figure 3.3- Methodology adopted for image de-noising by DWT, SWT and DWT techniques

E. IMAGE DE-BLURRING USING MULTI-RESOLUTION DOMAIN BASED TECHNIQUES

Image de-blurring is a process that minimizes the level of blur in a image corrupted with different type of blurs and a provide effective, efficient and powerful platform to de-blur the blurry images. This can be accomplished by applying the concept of the point spread function. Further, the point spread function is to be employed with the de-blurring methods to a obtain a sharper and clearer image. In other words, a unique point spread function is to be generated and thereafter, it is convolves with the images to form the blurry image. Moreover, additive white Gaussian noise is incorporated to the image to replicate a blurred noisy description of the understandable image.

Furthermore, the PSF is one of the most important variables that requisite to be computed and used with the deblurring procedure. System requires in order to spread a point of light. Here, in this study, the Gaussian point spread function is chosen as the basic PSF, also known as blur kernel.

There are many reasons for the image blur to be occurred in the image. The image blue can be classified into five different types of blur, namely, defocus blur, atmospheric turbulence blur, object motion blur, camera shake blur and intrinsic physical blur. In order to get a prefect image from the image contaminated with any of these blur, requires an appropriate modeling of blur kernel for the digital formation of image.

1) Image De-blurring by Discrete Wavelet Transform (DWT)

The description and methodology of DWT based deblurring technique, has already been discussed in this Section. The general methodology adopted for the de-blurring of images using DWT based image de-blurring technique has been discussed in subsequent D.3).

2) Image De-blurring by Stationary Wavelet Transform (SWT)

The description and methodology of SWT based deblurring technique, has already been discussed in Section D.2). The general methodology followed for the de-blurring of images using SWT based image de-blurring technique has been discussed in subsequent Section D.3).

3) Image De-blurring by Non Sub-sampled Contourlet Transform (NSCT)

The description and methodology of NSCT technique, has already been discussed in Section

The general methodology followed for the de-blurring of images by DWT, SWT and NSCT technique can be summarized as follows (Fig: 3.4).

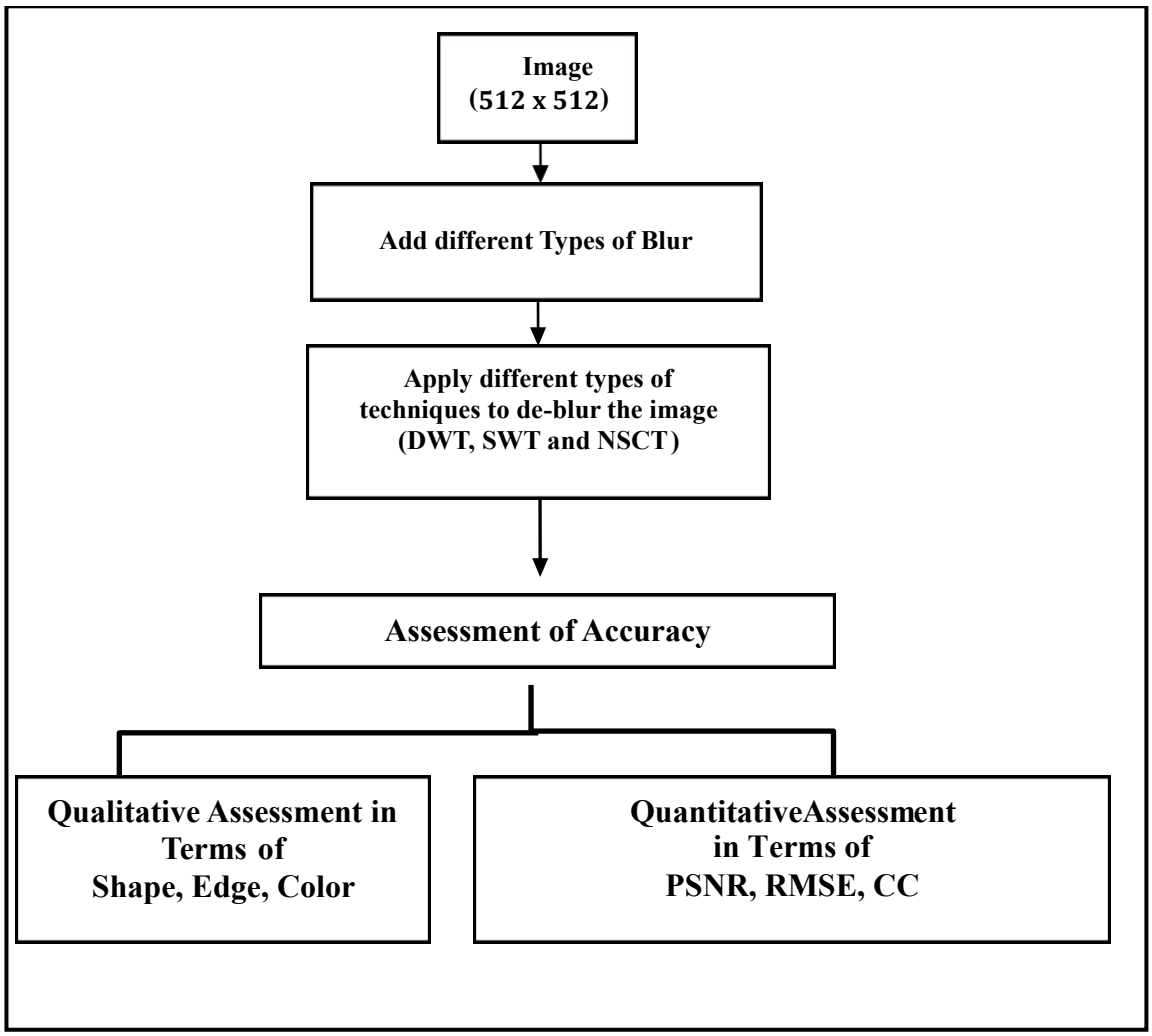

Figure 3.4- Methodology followed for image de-blurring by NSCT, SWT and DWT based techniques

The general methodology followed for the de-blurring of images using DWT, SWT and NSCT based de-blurry techniques can be briefed as follows (Fig: 3.4):

Decompose the blurry Image into a Contourlet and Wavelet domain.

Apply a calculated (estimated) PSF to the coefficients in the Contourlet and Wavelet domain to reconstruct the deblurred image, along with inverse Contourlet and Wavelet transform.

Different parameters are used to evaluate the fused images visually. These parameters are listed below

i. Colour Radiometry (CR) ii.
Shape of the feature (SF)
iii. Edge-Sharpening (ES)

Further, the de-noising techniques have been scored 5 to 1, corresponding to their visual quality, as shown in Table 3.1.

Table 3.1 Evaluation of quality of image by qualitative method

Absolute Measure	Relative Score
Excellent (E)	5
Good (G)	4
Above Average (AA)	3
Average (A)	2
Poor (P)	1

For a good de-noising of images assessed, the following conditions must be satisfied (Table 3.2).

Table 3.2 The ideal and error value of different metrics

S. No.	Metric	Ideal Value	Error Value
1	RMSE	0	
2	PSNR	NA	
3	CC	1	and

IV. METHODOLOGY ADOPTED

The flow chart shown in Fig 4.1 outlines the methodology adopted in this study.

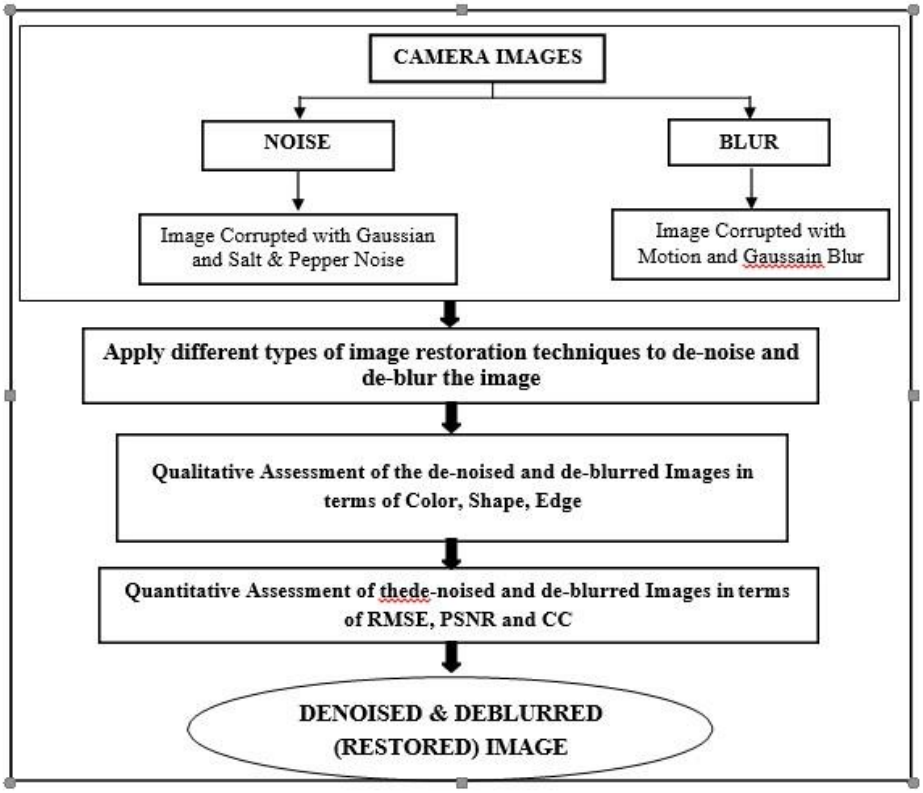

Fig. 4.1 Flow chart showing the methodology adopted

First of all, addition of different types of noise and blur to the input image is carried out. Thereafter, the de-noising and de-blurring (image restoration) process has been carried out using different image restoration techniques.

The de-noised and de-blurred image is then subjected to assessment of accuracy using qualitative and quantitative methods.

V. DATA USED

Overall, three types of camera images have been used to achieve the research objectives of section 1.3.Three camera images have been selected to carry out various experiments using image restoration techniques.

A. Camera Image 1 (DS-I1)Dataset

The dimensions of camera image 1 (DS-I) is (512 512) pixels. The sample imagery used for the experiments is shown in Fig. 5.2.

DS-I

Fig. 5.1 Camera Image 1 (DS-I1) dataset

The description of dataset (DS-I) is given below:

DS-I:

This is a image belongs to old building, consisting of features having linear and non-linear geometry, having maximum and minimum intensity values equal to 204 and 15.

B. Camera Image 2 (DS-I)Dataset

The dimensions of camera image 2 (DS-II) is (512 512) pixels. The sample imagery used for the experiments is shown in Fig. 5.2.

DS-II

Fig. 5.3 Camera Image 2 (DS-II) dataset

The description of dataset (DS-II) is given below:

DS-III:

This is a image belongs to pair of birds, consisting of features having linear and non-linear geometry, having maximum and minimum intensity values equal to 252 and 12.

VI. RESULTS AND ANALYSIS

A scrupulous investigation of the performance of the selected image restoration techniques have been carried out for different selected datasets in terms of visual and objective measures. Different datasets have been selected for the implementation of image restoration techniques with the motive to test the existing techniques under all possible scenario. For the purpose of comparison of results generated from different image restoration techniques, the same will be done both, visually and quantitatively for each data type.

Qualitative Analysis

As far as visual analysis is concerned, a subjective assessment of there stored images generated by different image restoration techniques has to be carried out in in terms of colour intensity, sharpness and missing details. Further, it is considered to be a effective way to point out the advantages and disadvantages of any image restoration techniques. As far as feature identification is concerned, different parameters are used to evaluate the restorated images visually. These parameters are listed below:

1. Colour Radiometry (CR)
2. Shape of the feature (SF)
3. Edge-Sharpening (ES)

Furthermore, these selected parameters have to be used for the purpose of subjective assessment. For subjective purposes, the restoration techniques have been scored 5 to 1, corresponding to their visual quality, as shown in Table 6.1.

Table 6.1 Evaluation of quality of image by qualitative method

Absolute Measure	Relative Score
Excellent (E)	5
Good (G)	4
Above Average (AA)	3
Average (A)	2
Poor (P)	1

Quantitative Analysis

In order to detect and recognize the minute difference among image restoration results, objective measures have to be applied. These differences cannot be noticed using visual approach. For these reasons, many researchers have developed efficient and effective objective indicators to capture the hidden information.

The accuracy of image restoration techniques have been evaluated quantitatively by using RMSE, PSNR and CC. Since, these metrics provides the spectral, spatial, as well as, geometrical similarity of the restored images. For the indication of good image restoration results, the quantitative indicators associated with the corresponding image restored images, generated by different restoration techniques has to satisfied the following conditions, The following conditions are listed in Table 6.2.

Table 6.2 Quantitative indicator represents ideal and error value

S. No.	Metric	Ideal Value	Error Value
1	RMSE	0	
2	PSNR	NA	
3	CC	1	and

VII. CONCLUSIONS

The present study has investigated the performance of various image restoration techniques for different camera images:

i. Visual and statistical analysis of result shows that NSCT based image restoration technique emerged as one of the most efficient and effective image restoration technique in terms of producing high quality image. ii. Analysis of results show that NSCT yields the highest performance in terms of different datasets, noise and bur variances and different metrics in comparison to SWT and DWT based image restoration techniques. iii. It can be inferred from this study is that the analysis of non-stationary image in the context of image restoration can be analyzed effectively and efficiently by using Non Sub- sampled Contourlet Transform based image restoration technique, followed by Stationary Wavelet Transform and Discrete wavelet Transform based restoration technique.

VIII. FUTURE SCOPE OF THE STUDY

This study has focused its attention on the restoration of camera images corrupted with different noise and blurs through different image restoration techniques, to produce images with good preservation of edges. Further, the following extension and applications are suggested:

i. Further, studies are obligatory to inspect, analyze and investigate the effect of image restoration on medical and satellite images.
ii. Further, studies are required to investigate the effect of speckle, as well as, poisson noise on different images.

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