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A Review on Image Denoising Techniques

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Abstract: The goal of this study is to find a "genuine" two-dimensional transform that can capture the fundamental geometrical structure that is important in visual information. The discontinuous character of the data is the most difficult aspect of analysing geometry in photographs. Unlike previous approaches, such as curvelets, which generate a transform in the continuous domain and then discretize for sampled data, we begin with a discrete-domain construction and then investigate its convergence to a continuous-domain expansion. We use nonseparable filter banks to create a discrete-domain multiresolution and multidirection expansion, similar to how wavelets are produced from filter banks. As a result of this construction, a flexible multiresolution, local, and directed picture expansion employing contour segments is obtained, and it is therefore useful.

I. INTRODUCTION

In the subject of image restoration, noise in an image is crucial. There are various types of noise that distort the visuals. One of the most difficult and least discussed issues is reducing noise in satellite photos. Speckle noise is a type of granular pattern that appears in radar coherent pictures.

The Synthetic Aperture Radar picture and aerial photographs both include a lot of speckle noise. In all coherent imaging technologies, such as laser, acoustic, and SAR imagery, speckle noise is a regular occurrence. The effect of speckle noise is unfavourable. Random interference between the coherent returns generated by the various scatterers present on the ground surface, on the scale of a wavelength of the incident radar wave, is the source of this sort of noise. This work aims to provide a thorough explanation of the speckle noise model in matlab and imaging analysis.

Image denoising is to abstract noise from a strepitous image, so as to renovate the veridical image. However, since noise, edge, and texture are high frequency components, it is arduous to distinguish them in the process of denoising and the denoised images could ineluctably lose some details.

Overall, recuperating consequential information from strepitous images in the process of noise abstraction to obtain high quality images is a paramount quandary nowadays.

In fact, image denoising is a classic quandary and has been studied for a long time. However, it remains a challenging and open task. The major reason for this is that, from a mathematical standpoint, image denoising is an inverse problem with no unique solution. Great advances in the field of picture denoising have been made in recent decades [1,2,3,4], and they are discussed in the following sections. Mathematically, the quandary of image denoising can be modeled as follows:

$$y=x+n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where y is the visually examined strepitous image, x is the unknown clean image, and n is additive white Gaussian noise (AWGN) with standard deviation n, which can be estimated in practical applications using a variety of methods, including median absolute deviation [5, block-predicted estimation [6, and principle component analysis (PCA)-predicted methods [7]. The goal of noise truncation is to reduce noise in natural photographs while preserving pristine features and improving the signal-to-noise ratio (SNR).

The following are the primary issues in image denoising:

1) Flat areas should be smooth; edges should be bounded without becoming blurred;
2) It's important to keep the textures, and
3) No incident artefacts should be created

We can't acquire the unique answer from the picture model with noise because solving the immaculate image x from Eq. (1) is an ill-posed problem. Image denoising has been well-studied in the field of picture processing for numerous years in order to produce a good estimation image x. In general, image denoising methods can be divided into three categories: spatial domain methods, transform domain methods, and hybrid methods, which are discussed in greater depth in the following sections.

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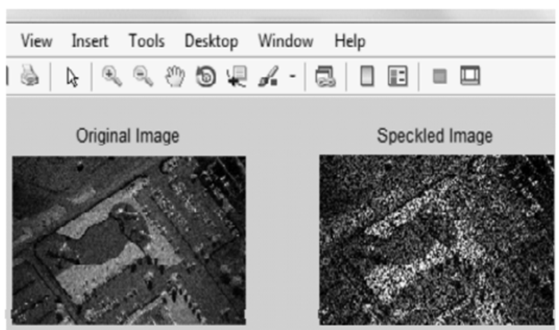
II. LITERATURE REVIEW

A. Noise Model With Speckles

This signal-dependent noise model aids in the smoothing of images in non-uniform locations when the signal is expected to be continuous Using the parameter á, the local variance to mean ratio, it is possible to determine whether the improvised pixel is within the uniform region or not. When the local variation to mean ratio is greater than the speckle, the pixel next to it is usually considered resolvable. Otherwise, it is considered to be in the uniform region, requiring smoothing [1]. The product of the speckle signal and the original noise, which is commonly referred to as multiplicative noise, is the resulting signal (Rayleigh noise). Let I I j) be the degraded picture pixel, and S I j) be the noise-free image pixel that has to be recovered. Speckle noise model,

I (i, j) = S (i, j) * N (i, j)…………………..(2)

1) *Manual Method Using Matlab Programming Algorithm*
a) Input image = SAR image.
b) Preprocessing: Checking RGB image if(input image = RGB image)
c) Convert RGB image to Grayscale image
d) Convert resultant image to double precision(I)
e) Else Convert Grayscale image to double precision(I)
f) Add speckle noise(s), by entering variance of the speckle noise to the I image, using AddSpecNoise() function file.
g) if(no. of input argument in function



2) *Classical Denoising Method:* Spatial domain approaches attempt to abstract noise by computing the grey value of each pixel based on the pristine image's correlation between pixels/image patches [8]. In general, there are two types of spatial domain methods: spatial domain filtering and variational denoising methods.
3) *Spatial Domain Filtering:* Since filtering is a major betokens of image processing, an immensely colossal number of spatial filters have been applied to image denoising[9,10,11,12,13,14,15,16,17,18,19], which can be further relegated into two types: linear filters and non-linear filters. Linear filters were used to abstract noise in the spatial domain in the past, but they failed to maintain image textures. For Gaussian noise minimization, mean filtering [14] has been used, although it can over-smooth pictures with large noise [15]. Wiener filtering [16, 17] has also been used to overcome this problem, but it can also easily blur sharp edges. Noise can be suppressed without any identification by using non-linear filters like median filtering [14, 18] and weighted median filtering [19]. Bilateral filtering [10] is commonly used for picture denoising as a non-linear, edge-preserving, and noise-minimizing smoothing filter. Each pixel's intensity value is replaced with a weighted average of intensity values from surrounding pixels. The efficacy of the bilateral filter is one issue. When the kernel radius r is astronomically large, the brute-force method takes O(Nr2) time, which is prohibitively expensive. Low pass filtering is used on pixel groups using spatial filters, with the language phrase that noise fills a higher frequency spectrum region. Ordinarily, spatial filters reduce noise to a reasonable degree, but at the expense of image blurring, which results in the loss of sharp edges. Image denoising methods have progressed throughout time, from the earliest spatial domain approaches to the most recent transform domain methods. The Fourier transform was the first transform domain method to be developed, but since then, a variety of transform domain methods have emerged, including the cosine transform, wavelet domain approaches [81,82,83], and block-matching and 3D filtering (BM3D) [55]. The following remark is employed in transform domain methods: in the transform domain, the qualities of picture information and noise are different.

B. Methods for Domain Filtering Transformations

In contrast to spatial domain filtering, transform domain filtering methods change the given noisy image to another domain before applying a denoising algorithm to the transformed image based on the image and noise's various features (larger coefficients denote the high frequency part, i.e., the details or edges of the image, smaller coefficients denote the noise). Transform domain filtering can be done in a variety of ways.

1) *Data Transformation That Adapts:* The transform techniques used on the given noisy images are independent component analysis (ICA) and PCA. The ICA method for denoising non-Gaussian data has been successfully implemented among them. The assumptions about the image-noise difference stay the same in these two techniques, which are data adaptive. They have a high computational cost since they use sliding windows and require a sample of noise-free data or at least two image frames from the same scene..
2) *Non-data Adaptive Transform:* The spatial-frequency domain and the wavelet domain are two domains in which non-data adaptive transform domain filtering approaches can be separated.
3) *De-speckling Procedures that are Commonly Used:* There are a variety of speckle reduction filters available, some of which provide better visual results. Others have good noise, while others have good interpretations. Powers of reduction or smoothing a few of the most well-known speckle noise reduction technique The median wiener filter, the Lee filter, and others are examples of filters. The kuan and frost filters are two types of filters. Some of these filters are spatially based. filtering in a well-known square moving window as in kerne. It only affects the centre pixel. and the pixels that surround it The dimensions of the The size of the filter window can vary from 3 by 3 to 33 by 33. 33, although the window's size must be unusual. If the size of the window is excessively large, because of this, vital information will be lost. If the size of the hole is too big for smoothing. If the window is too small, it will not provide the necessary light. good outcomes Typically, 3 by 3 or 7 by 7 are utilized, because it produces good results.

C. Contourlet Transform

Contourlets' enhanced approximation based on maintaining the most significant coefficients will assist compression, denoising, and feature extraction applications right away. Random noise, for example, will produce significant wavelet coefficients in the same way as actual edges do in image denoising, but it will be less likely to produce significant contourlet coefficients. As a result, simple thresholding is necessary. The contourlet transform is shown to be more effective at rebuilding smooth contours both visually and in PSNR. proposes a more complete denoising technique that accounts for dependencies across scales, directions, and locations in the contourlet domain using statistical modelling of contourlet coefficients, resulting in even higher improvements..

Fig1-a: Original image

Fig1-b: Original image with added noise

Fig1-c: Contourlet transformed image

III. CONCLUSION

We looked into many forms of de-speckle filters as well as wavelet-based techniques. Because all other filters have some drawbacks, such as not being able to eliminate speckle noise from the image adequately, the wavelet techniques outperform the best outcome better than the other filter techniques. In the instance of the wavelet-based approach DWT, it outperforms all other filters in terms of speckle noise reduction. Standard filters work well on ultra-high-resolution photos, but they have significant limitations in terms of resolution reduction. These filters are based on a fixed window that is set on a certain part before being moved to the next component and worked on. Some filters cause over-smoothing, which results in the loss of important information. Wavelets are the best because they have multiresolution, multi-scale, and sparse nature qualities.

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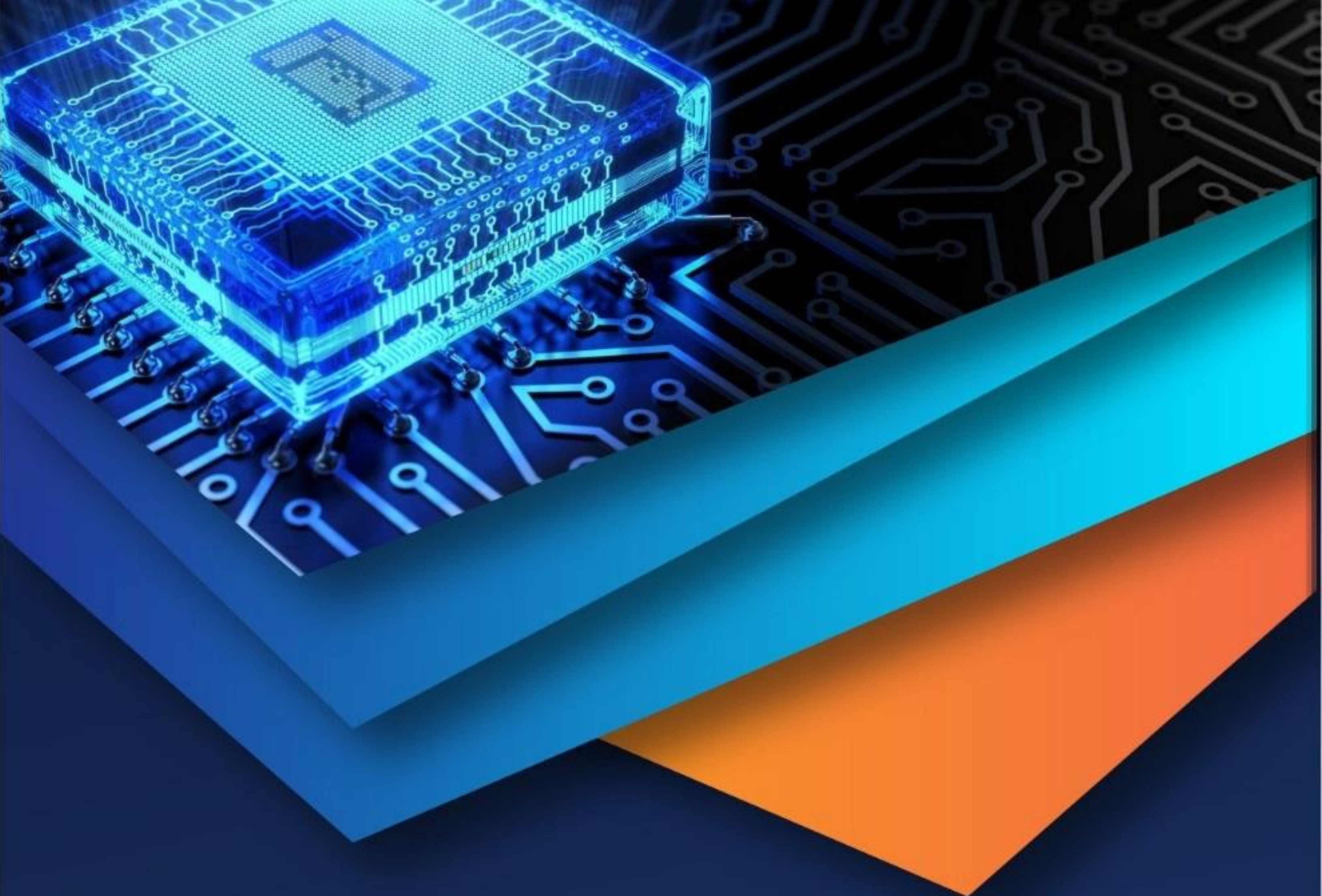

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