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SVD Based Noise Removal Technique: An Experimental Analysis

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Abstract: Digital Images have been widely used in various high end applications such as computer vision, surveillance, forensics, industries etc. Noise is one of the prominent issues that affect the further analysis of images. There are different types of noise such as salt and pepper noise, gaussian noise, periodic noise, speckle noise etc. In order to remove noise from digital images, large numbers of methods have been proposed. Using various filtering methods such as median filtering, linear filtering, frequency domain methods, noise can be effectively reduced. However these different methods give mostly domain specific results. Recently another technique called Singular Value Decomposition (SVD) has been used for a variety of methods of image analysis and synthesis. It has been applied in areas like image compression, face recognition, audio video signalling, remote sensing, pattern recognition etc. In this research paper, a new SVD based technique for removing noise from digital images has been proposed. This model has been implemented and tested for the selected domain of digital images. Images have been taken from both generated database as well as from standard database. The experimental results have been presented and analysed to detect different varieties of noise. The analysis of results indicates that the proposed SVD model significantly removes noise from the input digital image set. This model may further be explored for authentication of the digital images.

Keywords: Image authenticity, Singular Value Decomposition, Noise Removal, filter, gray images.

I. INTRODUCTION

Digital images have been widely used in the internet for various purposes in different areas like forensics, digital camera images, computer vision medical imaging, remote sensing, military, transportation, face recognition, speech recognition etc. However, some images are altered or manipulated by various image editing and processing open source or free software for either the benefit of the society or to harm the concerned area. This alteration may refer to intentional modification of an image in a way that would make it harmful to the consumer. The availability of low-cost hardware and software tools makes it easy to create, alter, and manipulated digital images with no traces [1] [2]. These altered images are prone to a variety of noises such as Salt and pepper, Gaussian noise, speckle noise etc. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are different ways through which noise can be introduced into an image, depending on how the image is created. If the image is scanned from a photograph made on film, the film grain may be a source of noise. Noise can also be the result of damage to the film or introduced by the scanner itself. Noise can also be generated during the electronic transmission of image data. As these images are used in various above mentioned areas, so our prime concern is to remove the noise before the images are processed further for various purposes such as computer vision, forensics, simulation, image processing etc. [3].

In order to remove such noise from digital images different methods are designed. Using various filtering methods such as median filtering, linear filtering, frequency domain methods, noise can be easily reduced. However the different methods give mostly domain specific results. Recently another technique called Singular Value Decomposition (SVD) has been used for a variety of methods of image analysis and synthesis. It includes areas like image compression, face recognition, audio video signaling, remote sensing, pattern recognition etc. SVD is a very robust technique. The SVD method involves refactoring of given digital image in three different feature based matrices. The singular values set preserve the significant features of the original image which helping in detection and removal of large extent of different types of alterations in digital images.

A. Mathematical Model of SVD:

SVD is a factorization of a real or complex matrix. The singular value decomposition of an m×n real or complex matrix M is a factorization of the form

$$M=U\Sigma V^T \text{ where}$$

U = m×m real or complex unitary matrix

Σ= m×n diagonal matrix with nonnegative real numbers on the diagonal.

V^T= n×n real or complex unitary matrix. [4] [5].

Most of the SVD based approaches gives satisfactory results in different areas. In this research study, a novel SVD based noise removal model has been proposed. The proposed model has been implemented and tested for the set of images. These set of images have been taken both from user generated database as well as from standard database. The behavior of this model has been studied to detect different varieties of noises by studying the extent of noise removal from static digital images. The preliminary investigations show that a considerable degree of noise can be removed from the input digital image set using the proposed SVD based model.

II. BACKGROUND

Noise in digital static images consists of any undesirable flecks of random color in a portion of an image that should consist of smooth color. It is somewhat similar to the snowy appearance of a bad TV signal. Digital images shot in low light or with a high setting often exhibit this undesirable noise. Image noise is an undesirable bye product of image capture that adds spurious and extraneous information. These distorted images effect the authentication or correctness of digital images because these images are used in different areas of our environment. This tampered or noisy image results in wrong information due to unwanted content of data or disturbed noise particles. Thus there is a great demand to remove such noise from digital images so that images used in different areas produce the accurate results. Depending upon different types of noise multiple techniques are suggested by different researchers to remove noise from digital images.

Images taken with both digital cameras and conventional film cameras will pick up noise from a variety of sources. Many further uses of these images require that the noise will be partially or fully removed. There are different types of noise associated with digital images such as- salt and pepper, Gaussian noise, periodic noise, speckle noise etc. A wide variety of filtering algorithms have been developed to detect and remove noise leaving as much of possible of pure image. Linear filtering method removes certain types of noise. Certain filters such as averaging or Gaussian filters are appropriate for this purpose. Averaging filter is useful for removing grin noise from a photograph. Median filtering is another method to remove noise without reducing the sharpness of the image. Another method called smoothing is to reduce noise and improve the visual quality of image. A number of procedures that are applied to static imaging produce no qualitative outcomes. These above discussed methods are very much efficient but they possess some limitations [6]. Thus the prime focus of this research study is to remove the noise from static digital images efficiently.

III. LITERATURE REVIEW

Different researchers have proposed various methods and techniques of detecting and removing noise from digital images. Various methods are under considerations which help to detect different types of noise in digital images. However, there is hardly any method which can handle all the alterations of noise. On the basis of a comprehensive literature survey and understanding the various techniques and algorithms proposed by different researchers a novel SVD based noise detection model has been proposed in this research work. Some of the significant research work in this area has been presented below. Another denoising scheme to restore images degraded by CCD (Charged Couple Device) has been proposed by Faraji et al. The CCD denoising scheme is a combination of signal independent and signal dependent noise terms. However, this model becomes more complex in image brightness space due to nonlinearity of the camera response function that transforms incoming data from light space to image space. As per the experimental results the researchers suggest that light space denoising is somehow efficient. New fuzzy filter is presented for the reduction of additive noise for digital color images by designing two sub filters. These correct the pixels where the color components differences are corrupted to their environment. This method reduces the noise by using only edge detection method [7].

Chiange et al. studied the noise reduced method for stripped image. The gray value substitution and wavelet transformation are satisfactory in stripped noise reduction. This model reduces the noise from stripped image [8]. Kumar et al. discuss feature extraction in digital image analysis. Gaussian noise removal method for removing noise from image collected is applied and then edge detection method is applied. Linear filters are not able to effectively estimate impulse noise as they have a tendency to blur the edges of an image. On the other hand non-linear filters are studied by Kavitha et al. to deal with impulse noise [9] [10].

A new method is introduced by Lysaker et al. for image smoothing based on a fourth order PDE (Partial Differential Equation) model. This method is tested on a broad range of real medical magnetic resonance images. This algorithm demonstrates good noise suppression without destruction of important anatomical or functional detail even at poor signal to noise ratio. It is a finite difference based additive operator method that allows much larger time slots [11].

The SVD based decomposition tampering detection model transforms the image into different mutually compatible matrices that can express the various relationships among the original data items. SVD is applied to digital images which help to reduce or compress the digital images and identify the most affected regions in tampered digital images. The mathematical model of SVD is defined by G. Gul et al. The technique allows refactoring a digital image in different segments called singular values. These singular values represent the image as a smaller set of values, which preserve useful features of the original image. SVD utilizes less storage space in the memory, and achieve the image compression process [12].

SVD based methods are applied in the area of image restoration. The designed method is implemented by adjusting the singular vectors of the digital image. Large number of singular values and corresponding singular vectors are computed to obtain certain regularization. H. Packard proposed noise estimation and filtering method based on singular value decomposition and compression based filtering. Experiments show that the proposed filter preserves edge details and can significantly improve the noise from video sequences [13]. Another filtering action to cancel noise from image is studied by J. Harikiran et al. He proposed a novel technique for impulse noise reduction. The noise is filtered in parallel with five different smoothing filters [14]. SVD has many applications in image processing. SVD can be used to restore a corrupted image by separating significant information from the noise in digital image data set. T. Workaleman et al. outlines different problems in digital image processing along with SVD filtering, image compression etc. [15].

IV. METHODLOGY

As discussed above the digital images are used for multiple purposes in different areas. These images are easily prone to a variety of distortion such as noise by various methods. Thus by retrieving results on the basis of these altered images produces ambiguous information. In order to overcome such problems, a novel SVD based noise reduction model has been proposed. This model removes the noise from static digital images. Recently, SVD is being increasingly used in various applications of distortion areas. As explained above, SVD is a very robust technique. The SVD method involves refactoring of given digital image in three different feature based matrices. The small set called singular values preserve the useful features of the original image which helps in detecting or removing large extent of different types of alteration in digital images. Fig.4.1 shows the Schematic diagram of SVD based Noise Removal Model.

The proposed model has been implemented and tested for three different set of images. Images have been taken from both generated database as well as from standard database as shown in Fig. 4.2. These image sets can be categorized as: Set A- Images from standard database [16]. Set B- comprises of synthesized images containing different geometrical patterns. In set C, the collection of the images is from the peripheral image capturing devices. For this study the real images have been taken from a 8 Mbps digital camera. The image size has been normalized to 150x150 and only bit mapped format has been considered to maintain uniformity of the results.

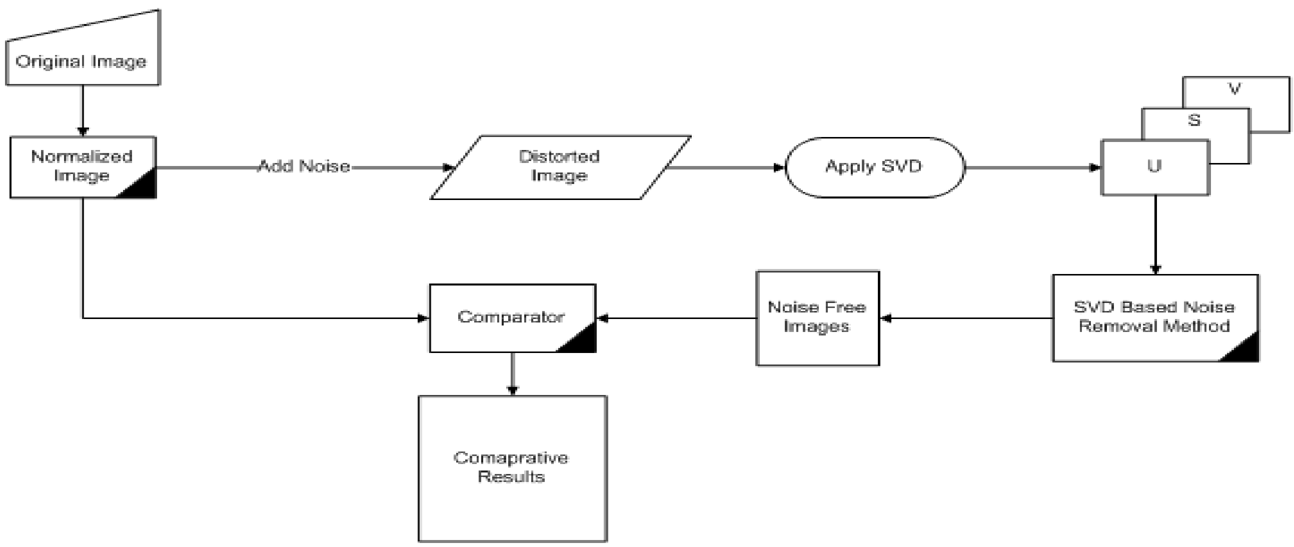

Figure 4.1 .Schematic diagram of SVD based Noise Removal Model.

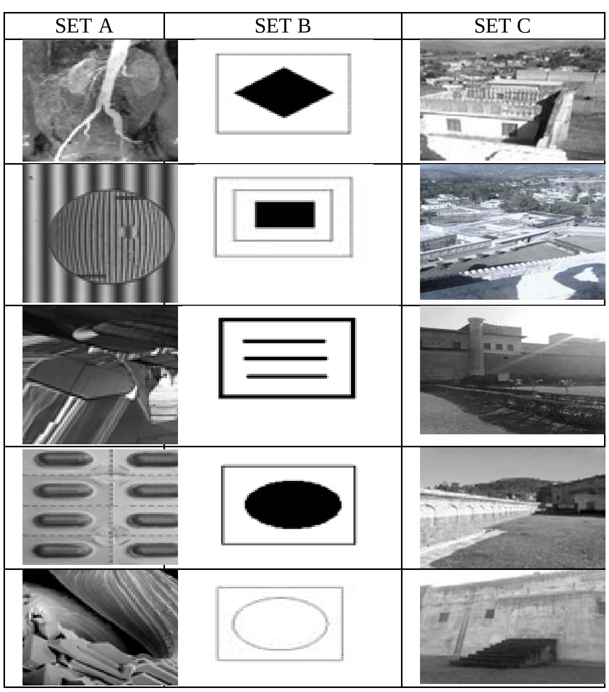

Figure. 4.2 Image Data Sets used for testing.

Image from any of the three sets can be selected for processing. Input image is then normalized in suitable format. After preprocessing salt and pepper noise is then added to the test image for implementing and testing the proposed model. The Salt and pepper noise is added under different mean values ranging from 0.2 – 1.0. Value at mean 0.2 is considered to be the least noise added to the image whereas the value at mean 1.0 is the maximum amount of noise added. After this SVD is applied to the input image so that the useful image features can be extracted. These features are stored in the form of three matrices namely U, S, V. On the basis of these matrix values a proposed SVD based algorithm is applied. The proposed algorithm calculates the percentage of noise introduced in the test image and also displays the amount of noise removed from the distorted image. The results against different noise variations are studied further and compared with the original image to verify the authenticity of the proposed model.

V. RESULTS AND DISCUSSIONS

This section presents the experimental results illustrating the performance of the proposed SVD based noise removal technique. The result shows the behavior of the SVD with respect to noise present in test images. As shown in Fig 4.1, SVD is applied to the test image and useful features were extracted in the form of U, S, and V matrices. After that the noise can be removed the noise from test images using the proposed algorithm. The visual outputs of test image gave satisfactory results. For empirical analysis, the output of given image was compared using distance evaluation formula with the corresponding input image. In order to check the effectiveness of the proposed model, extent of noise removal was evaluated by comparing the output and the original input image. This comparison between the original image and the resultant image obtained after removing the noise (in terms of %age) using the proposed technique has been shown in Table 5.1.

The output has been calculated for three image datasets- Set A, Set B, Set C. As depicted from above table, it is observed that noise from Set A and set C has been removed up to a great extent i.e. 99% whereas noise removed from Set B lies between 78% - 99%. This indicates that the proposed SVD based noise removal model works efficiently for Set A and Set C. Set B also gave satisfactory results but with little variation. These variations of results can be due to the complexity of the image. Thus from the above experimental results, it can be concluded that the noise removal process depends upon the complexity of the images, higher the complexity more efforts are required to remove the noise. The investigation indicates that this model may further be explored for authentication of the digital images.

Table 1 Extent of noise removal in different sets of the input images (in percentage).

	SVD based Model vs. Original Image (in %)	
Image Set A	**I1**	99.5600
	I2	99.6005
	I3	99.6300
	I4	99.6041
	I5	93.4081
Image Set B	**I6**	87.6678
	I7	87.6706
	I8	99.5949
	I9	78.7184
	I10	99.6623
Image Set C	**I11**	99.5432
	I12	99.6156
	I13	99.4148
	I14	99.5904
	I15	99.5147

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VI. CONCLUSION

In this research work, SVD based noise removal model has been proposed and investigated. The variation in SVD model with respect to noise at different mean values is calculated. Comparison between the original image and the results obtained from the proposed SVD based model are analyzed. The results obtained show considerable removal of the noise from the tested digital images. Further investigations are required to comparatively analyze effectiveness of SVD based noise removal model with different standard noise removal methods. A larger and wider set of images may be tested for further analysis. The investigation show considerable noise reduction in the input image. This model is further being investigated for ascertaining the authenticity of the images.

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