Enhancement and Edge Extraction of Satellite Images.

Remya.K.R, Aiswarya Raj

Abstract—Satellite images have become a very important part in many fields of research. In most of the cases, the satellite images are corrupted by the presence of noise .In the proposed method we are enhancing the contrast of satellite image for extracting edge details. Lot of information is available even in a small area of a satellite image .Hence it is very important that the image can be enhanced to the best possible extent to get maximum detail out of the available satellite image for research applications. Edge detection is another key parameter in the Satellite Imaging. The Edges represent significant intensity variation with in an object. The changes in edges of satellite images represent the Geographical changes. Hence proper Edge detection in satellite images is of paramount importance. Proposed Method consists of two parts. In the first part, the contrast of the image is enhanced by log average luminance analysis and intensity transformation with ant colony optimisation. In the second part, the edge detail of the enhanced image is extracted. Proposed technique is tested on different satellite images. Experimental results shows that edges are preserved better in the case of proposed contrast enhancement technique compared to other conventional methods of enhancement.

Index Terms—Integer wavelet transforms (IWT), log average luminance analysis, Knee transfer function, Gamma transfer function, singular value decomposition, Discrete wavelet transform (DWT), Principle Component analysis (PCA), General Histogram equalisation (GHE)

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1 INTRODUCTION

In recent years there has been an increased demand for good quality satellite images in various fields of research. Most of the remote sensing applications such as image registration, image segmentation and region separation use edge detection as a pre-processing stage for feature extraction. In most of the cases satellite images, can be corrupted because of the presence of the noise.

The real problem is finding a way to enhance noisy remote sensing images and to extract edges properly. In the proposed method we enhance the remote sensed image first and after that by using edge detector, the edge detail of an image is extracted. Image enhancement is based on log average luminance analysis and Intensity transformations. Here intensity transformation is done by Knee transfer function followed by gamma transfer function. Ant colony Optimization technique is used to find knee points for the calculating Knee transfer function.

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The proposed method enhances the overall quality of the image with minimum pixel distortion. Hence by applying edge detector to the enhanced remote sensed image we can detect the edges more precisely. Proposed technique is compared with edges detected by the images enhanced by other contrast enhancement techniques, such as General histogram equalization, DWT based SVD, DWT based PCA. General Histogram equalization [1] (GHE) is one of the most common methods for image enhancement. Based on the statistical characteristic of an image, intensity transfer function can be automatically defined by histogram equalization method .But in the case of GHE; brightness of the image is not preserved.

Satellite image enhancement by singular value decomposition proposed by Demrial and Anbarjafari [2] is another method of enhancement in the transform domain. This method of enhancement is based on discrete wavelet transform and singular value decomposition (SVD). Edge details are not preserved in this method of enhancement.

Principal component analysis is another tool for enhancing the contrast of an image. R Vani and R. Soundararajan [3] propose a method for contrast enhancement based on discrete wavelet transform and Principle component analysis .It will enhance overall quality of an image and edges are persevered in this case far better compared to Demrial method. However brightness is not preserved in this method of enhancement.

In the proposed method , edge detectors used for extracting the edge details of enhanced satellite images are range filter, canny operator and sobel operator..

2 Proposed Method.

Proposed method has two steps. Image Contrast enhancement is done in the first step and edge detection is done in the second step.

Fig .1. overview Of Proposed Method
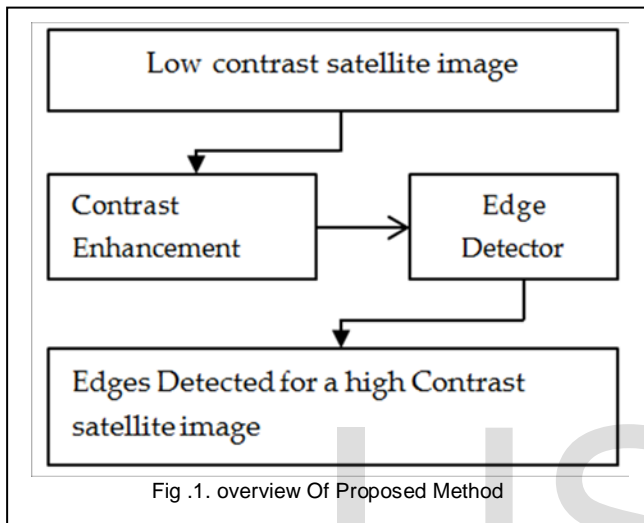
Overview of proposed method is shown in figure1. In the proposed method low contrast satellite image first undergoes through contrast enhancement technique and later on the enhanced image will act as an input to edge detector.

2.1 Contrast enhancement of Satellite Image.

Detailed algorithm and block diagram of proposed method is explained in the figure 2. Image enhancement is used as a pre processing techniques for edge extraction of satellite image. In this method of enhancement initially we decompose the low contrast input image into four subband images using integer wavelet transform. Integer wavelet transform is implemented using lifting based discrete wavelet transform. After that log average luminance in the LL subband is calculated .Log average luminance is calculated by the following equation.

$$Q(x,y) = \exp(\frac{1}{S} * \sum_{R \in (x,y)} (x\{logL(x,y) + \beta\}) \qquad (1)$$

Where R represents the rectangular region containing the coordinates (x, y). S represents total no of pixels in R. β is a small constant.

Normalized dominant brightness varies from zero to one. Depending on the transformed intensity value LL sub band is split into three layers. In the low intensity layer all the pixels have log average luminance less than 0.4. Layer in which all the pixels have the log average luminance in between 0.4 and 0.7 is called middle intensity layer. Layer in which all the pixels have log average luminance greater than 0.7 is categorised as high intensity layer .Next we have to adaptively transfer the intensities in each layer in order to perform proper contrast enhancement. Adaptive intensity transformation is a combination of Knee transfer function and Gamma transfer function.

2.1.1 Knee transfer function with ant colony optimisation

In order to perform Knee transfer function first we have to calculate the knee points. Knee points are the points from where the slope of intensity transfer will vary. For each layer knee points are different .Middle intensity layer has two knee points where as high intensity layer and low intensity layer has only one knee point. For low intensity layer knee points are calculated by

$$K_l = L_b + t_l(L_b - M_l) \qquad (2)$$

Where K_l represents knee point intensity, t_l is the tuning parameter, L_b is the low bound and M_l is the mean of low intensity layer.

$$K_h = H_b - t_h(H_b - M_h) \qquad (3)$$

Where K_h represents knee point, t_h is the tuning parameter, H_b is the high bound and M_h is the mean of high intensity layer. Following two equations are used to calculate knee points for middle intensity layer

$$K_{ml} = L_b - t_m(L_{ml} - M_m) + (K_l - K_h) \qquad (4)$$

$$K_{mh} = H_b + t_m(L_{mh} - M_m) + (K_l - K_h) \qquad (5)$$

Where K_{ml} and K_{mh} represents knee points for middle intensity layer, t_m is the tuning parameter, H_b is the high bound and M_m is the mean of middle intensity layer. Tuning Parameters for Low, high and middle intensity layers are calculated using ant colony optimisation technique.
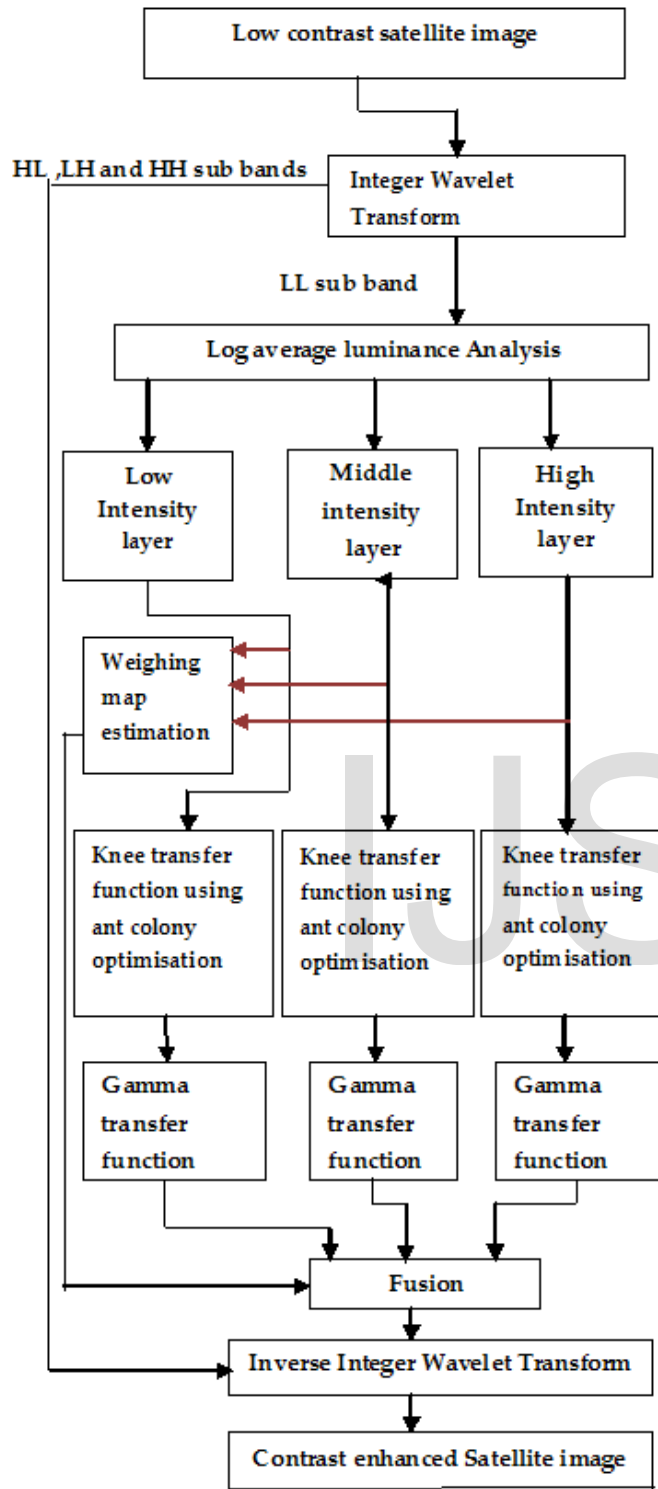
Fig. 2 Block diagram for proposed enhancement method

Ant colony optimisation [5] is a probalstic technique for solving computational problems. Ant colony optimization is a general search technique which has been inspired by pheromone track behaviour of real ant colonies. Here ant

colony optimization technique is used as a key technique for finding the Knee transfer function. Tuning parameter for high intensity layer, low intensity layer and middle intensity layers are calculated using this optimisation technique.

2.1.2 Gamma transfer function.

The three intensity layers are applied with gamma transfer function to compensate the distrotion caused by the images by applying Knee transfer transfer function. Gamma transfer function T_g (L) is given by the following equation

$$T_g\ (L) = \left\{ \left(\frac{L}{X_p} \right)^{\frac{1}{\gamma}} - \left(1 - \frac{L}{X_p} \right)^{\frac{1}{\gamma}} \right\} \tag{6}$$

For low intensity layer X_p is equal to L_b, for middle intensity layer X_p is equal to $L_b - H_b$ and for high intensity layer M_p is equal to 1- H_b. L represents the intensity value. γ is a constant.

2.1.3 Weighing map estimation

Bit plane extaaction is the key technique for weighing map estimation.Using bit plane slicing image is sliced at different planes ranges from bit level 0, which is the least significant bit (LSB) to bit level 7 ,which is the most significant bit(MSB). An eight bit image may be considered as being composed of eight one bit plane. In order to calculate weighing map, decompose each layer prior to intensity transformation into eight planes.Extract most significant two bits from each layer.Add the extracted bits in each layer in order to calculate weighing map for each layer separetely.First and second largest weighing maps are selected for image fusion.

 Three enhnaced layers are fused   according to the following expression

$$F = L_W \times e_l + (1 - L_W) \times \{ S_w \times e_m + (1 - W_l) \times e_h \} \tag{7}$$

 where L_w represents the largest weighing map, S_w represents the second largest weighing map, e_l , e_m and e_h represents enhanced low intensity layer , middle intensity layer and high intensity layer respectively.

Resultant Enhanced Image is obtained by calculating Inverse integer wavelet transform of modified LL subband to gether with other sub bands.LL sub band contains most of the illumination information.In this proposed method of enhncement, we are enhancing the image by changing the illumination information.Beacuse of this reason we haven only LL sub band for intensity transformation for enhancement. But LH, HL and HH sub band contains the edge details of an image .Hence we have to take inverse integer wavelet transform of the transformed LL sub band together with remaing three sub bands to get better edge preserving equalised image.

2.2 Edge detection

Process of identifing and locating sharp discontuity in an image is refered to as edge detection. Here we are using three different type of edge detectors such as range filter , sobel operator and canny operater to detect the edges of remote sensed images.
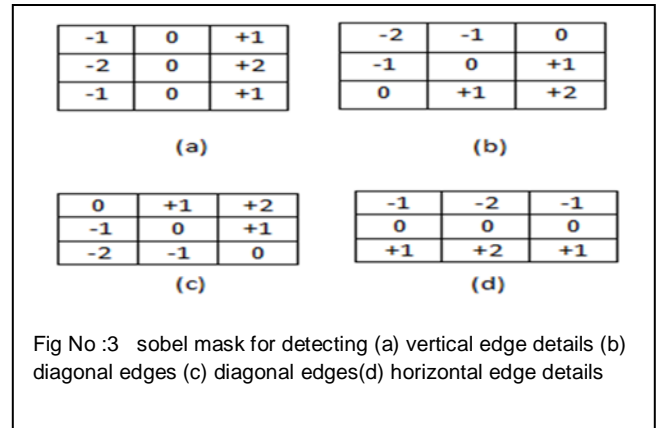
2.2.1 Range filter

Range filter is used to find the edge and surface details of an image. Range filter, filter the image by replacing every pixel by difference of maximum and minimun in its neighbour hood.

2.2.2 Canny operator.

Most commonly used edge detector in computer vision is Canny operator.The advantage of canny operator is that it reduces the probability of occurance of detecting an edge several times and minimises the probability of failing to detect an edge.Canny uses thresholding with hysteresis. Canny method find edges by looking for local maximum of gradient of an image.Canny method uses two threshold to detect weak and strong edges. if weak edges are connected to strong edges then they are included in the ouput.
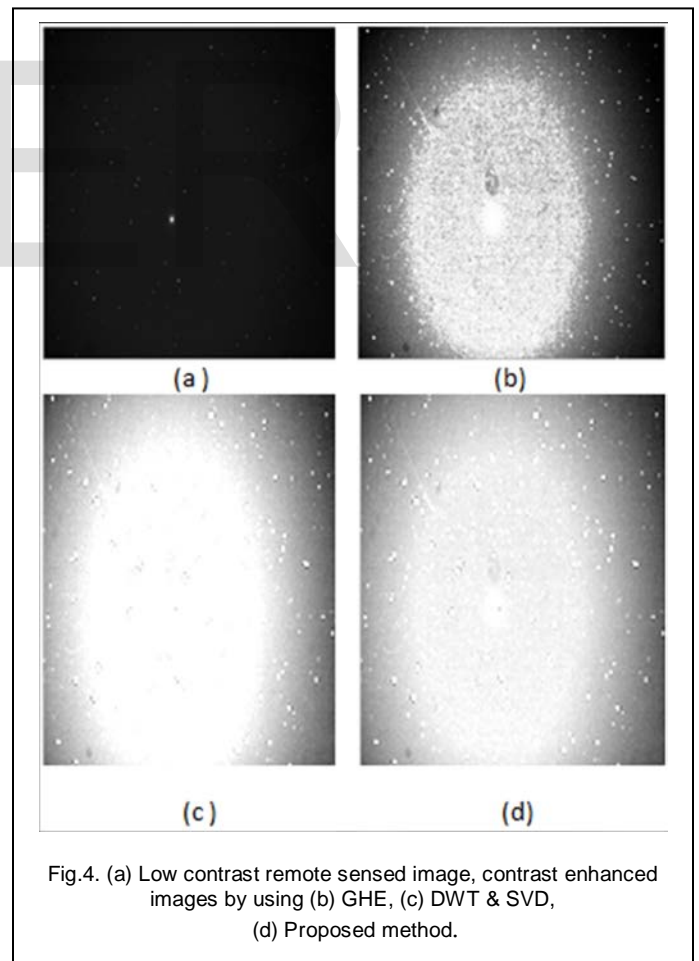
2.2.3 Sobel operator

Sobel operator is a discrete differentiation operator.Sobel operator consist of a pair of 3X3 convolution kernels. Figure 3 shows the masks for sobel operator .Sobel operator performs 2D spatial gradient measurement of an image.

Fig No :3   sobel mask for detecting (a) vertical edge details (b) diagonal edges (c) diagonal edges(d) horizontal edge details

3 PERFORMANCE ANALYSIS

The proposed technique has been tested on different satellite images using Mat lab 7.2 or higher version as a software tool.

Fig.4. (a) Low contrast remote sensed image, contrast enhanced images by using (b) GHE, (c) DWT & SVD, (d) Proposed method.

The performance of the proposed algorithm is compared with existing well-known algorithms including standard HE, DWT based SVD and DWT based PCA using different type of edge detectors. It is observed that using the proposed method of enhancement, edge details of the image is preserved more compare to other conventional method of enhancement. Figure 4 shows the comparison of proposed enhancement technique with other conventional methods of contrast enhancement. It can be observed that there is significant improvement in contrast of satellite image compare to other methods.
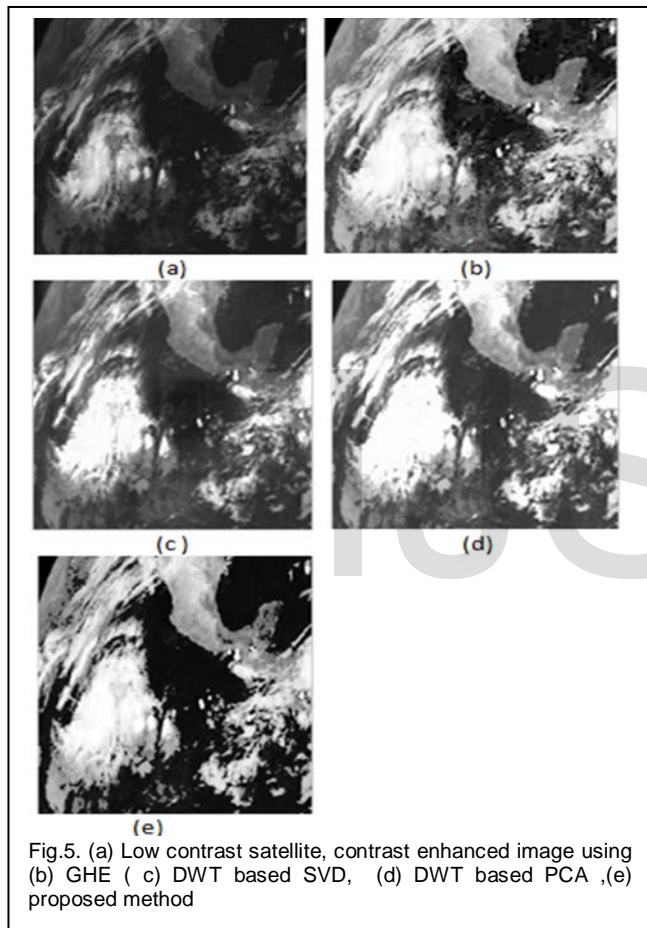

Fig.5. (a) Low contrast satellite, contrast enhanced image using (b) GHE (c) DWT based SVD, (d) DWT based PCA ,(e) proposed method

Figure 5 shows the comparison of proposed enhancement technique with other conventional methods of contrast enhancement. It can be observed that there is significant contrast enhancement in the proposed method compare to other methods. Proposed method of enhancement reduces the pixel distortion while enhancing the contrast. Visual results clearly indicated that the brightness as well as edges of satellite image is better preserved in the case of proposed method compared to other methods of enhancement. Image enhancement techniques are used as pre-processing tool for
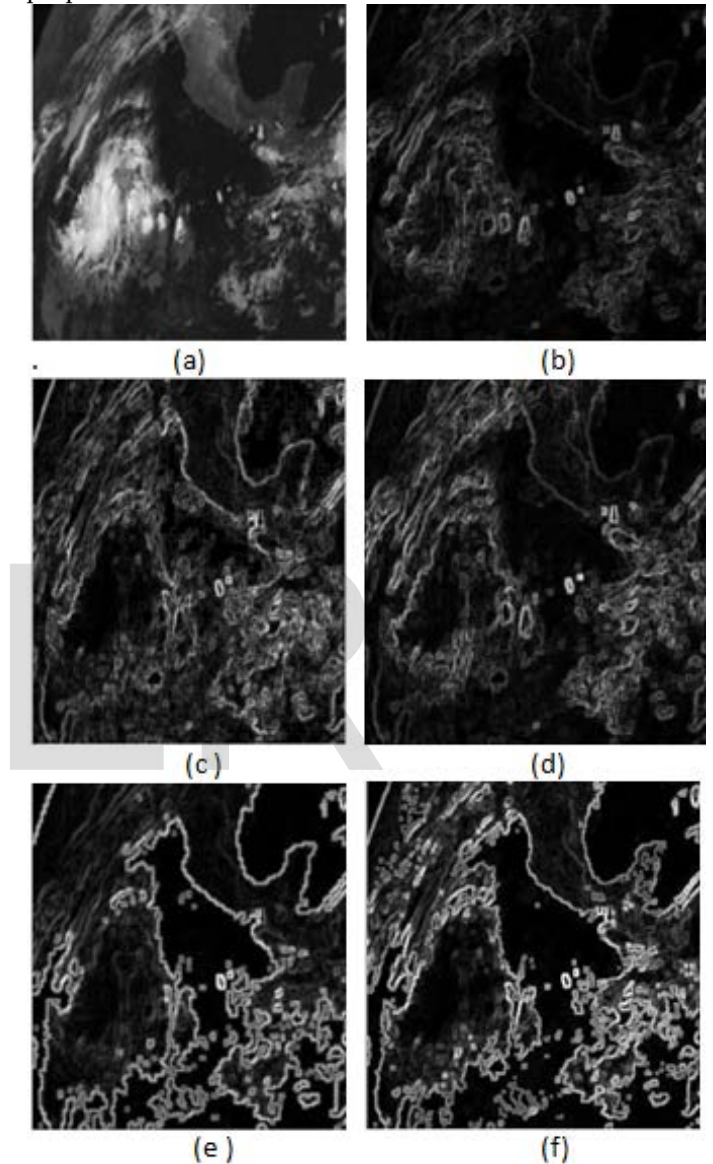
extracting the edges of satellite images. Figure 6 shows the comparison of edges extracted using range filter in an image that is enhanced by proposed method with other conventional methods of contrast enhancement. Simulation results show that edges are better preserved in the proposed method.
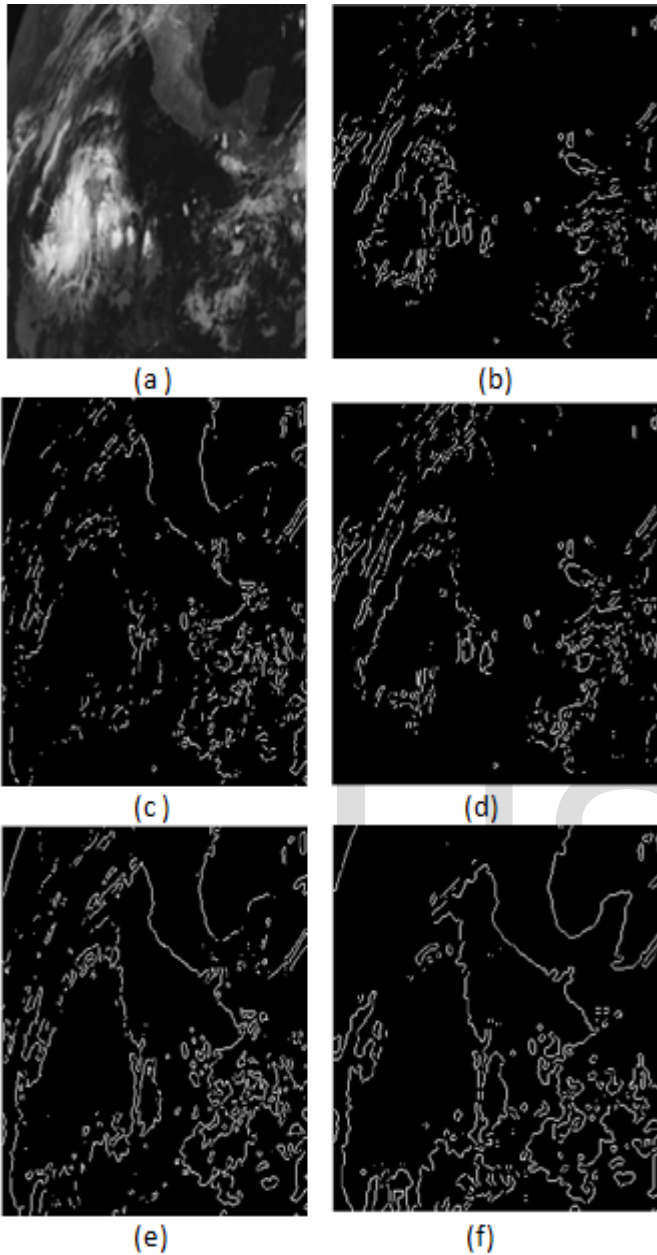

Fig.6.(a)Low contrast satellite image, edges detected using range filter in (b) low contrast image , (c) contrast enhanced image using GHE, (d) contrast enhanced image using DWT based SVD ,(e) contrast enhanced image using DWT based PCA, (f) contrast enhanced image using proposed method

Fig .7. (a)Low contrast remote sensed image, edges detected using sobel operator in (b) low contrast image ,(c) contrast enhanced image using GHE, (d) contrast enhanced image using DWT based SVD ,(e) contrast enhanced image using DWT based PCA, (f)contrast enhanced image using proposed method.

Figure 7 and 8 shows the comparison of edges extracted using sobel operator and canny operator respectively. In both cases simulation results shows that edges are more preserved in an image that is enhanced by proposed method compare to other method of enhancement.
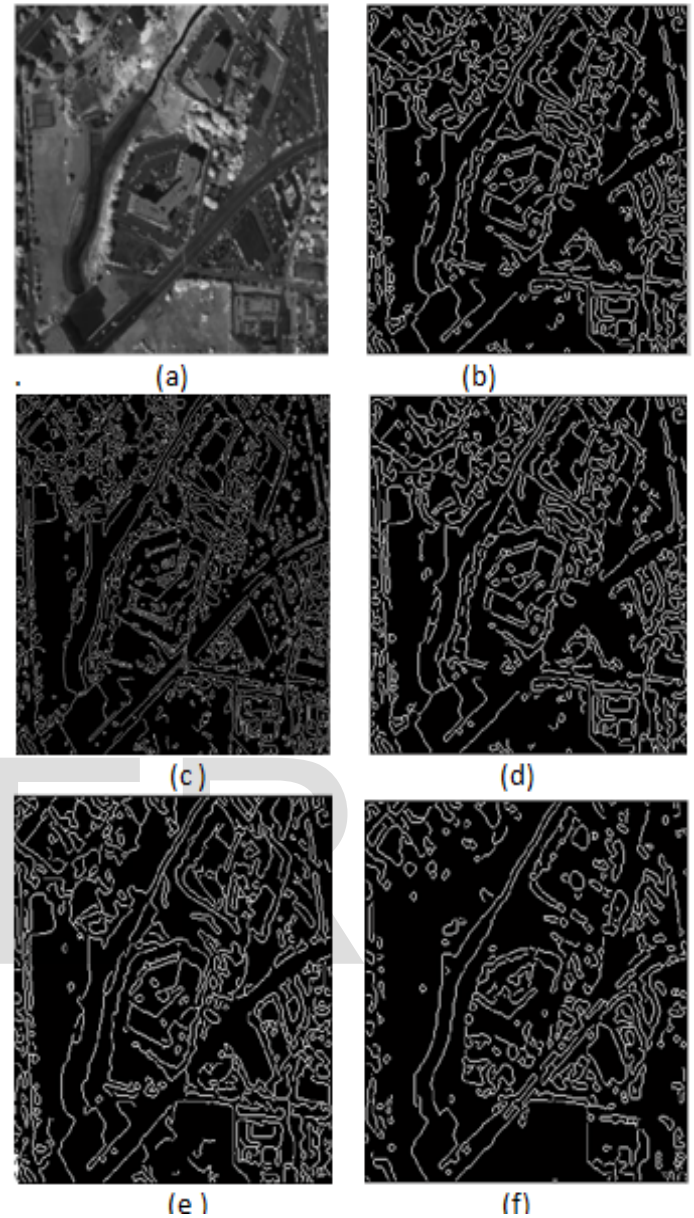
Fig.8.(a)Low contrast remote sensed image, edges detected using Canny operator in (b) low contrast image , (c) contrast enhanced image using GHE, (d) contrast enhanced image using DWT based SVD (e) contrast enhanced image using DWT based PCA,(f) contrast enhanced image using proposed method.

Canny operator maximise the signal to noise ratio and minimise number of response to single edge. From the visual results it is observed that edges are detected more accurately in the case of proposed method of enhancement.

4 CONCULSION

Proposed method enhances the overall contrast of image with minimal pixel distortion. Hence edges are detected more precisely for this method compared to other conventional methods of enhancement. Detecting the edges of a satellite image after enhancing the contrast of the same is the basic idea behind the proposed method. Contrast of the image is enhanced by analysing the log average luminance together with gamma and Knee transformation. Ant colony optimisation technique is used for calculating Knee transfer function. Edge of contrast enhanced image is detected using Sobel operator, range filter and canny operator. Simulation results demonstrated that edges are detected more effectively in the case of images that are enhanced by proposed method than other methods.

ACKNOWLEDGMENT

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