Cluster Computing
https://doi.org/10.1007/s10586-017-1508-x

Edge detection of satellite image using fuzzy logic

R. Dhivya[1] · **R. Prakash**[2]

Received: 4 September 2017 / Revised: 28 November 2017 / Accepted: 9 December 2017
© Springer Science+Business Media, LLC, part of Springer Nature 2017

Abstract
Edge detection plays an important role in the field of image processing. Various edge detection techniques are obtained like Sobel, PSO Preweitt, Laplacian and Laplacian of Gaussian. These techniques consume some restrictions such as fixed edge thickness and some parameter like threshold is problematic to implement. Although many different edge-detection methods have been proposed for gray-scale, color, and multispectral images, they still face difficulties when extracting edge features from hyperspectral images (HSIs) that contain a large number of bands with very narrow gap in the spectral domain. High performance computing (HPC) is a technique used to assemble process and analyze more quantity of remote sensing (satellite) data which needs less processing time. HPC method is used in distributed & cluster Computing, parallel computing and following satellite data analyzing & processing approaches like geo-referencing, image edge detection, image classification, image mosaicking, Morphological/neural approach and image fusion for hyperspectral satellite data. Stimulated by means of the specific clustering of theory called gravitational theory, an original edge detection process. The conservative methods include the usage of linear time invariant filters. Recognition of edge is done by these filters as a These filters recognize an edge as a sudden conversion of grey scale pixel intensity. These techniques are well recognized and computationally effective. Canny, Sobel, Robert, Kirsch, Prewitt and LOG, on idea of spatial differential filters by using local grade. Within the less time these filters process the data and are inclined to noise. But in fuzzy technique, it does not include like this restriction, by altering the rules and output parameters, it is possible to change the thickness of the edge. In this paper, a new technique is created on fuzzy logic, which is suggested for detection of edge in digital images deprived of finding the threshold value. This method starts through segmenting the images into sections by means of fluctuating 3×3 binary matrixes. The pixels of edge are planned to a range of standards separated from each other. The results of this proposed technique is compared with the results obtained from PSO and neural network methods. This suggested technique provides a permanent effect in the lines smoothness and straightness for the straight lines and good roundness for the curved lines. And sharpness in the curves.

Keywords Hyperspectral images · High performance computing · PSO · Neural edge detection · Fuzzy logic

1 Introduction

The important goal of this edge detection processing in image is to give permanent effect in the lines smoothness and straightness for the straight lines and good roundness for the curved lines and the image corners are sharper by using fuzzy logic method. Before this, many methods are done regarding this image process but those methods did not meet this requirement. But our proposed method meets these results and gives exact results which helps in the future work also. Hyperspectral imaging collects the information and developments data through the electromagnetic range [1].

High performance computing (HPC) is the new advanced method in the arena of computer science, which grown to meet the demands for processing time and speed. HPC composed numerous techniques such as computer architecture, system software, algorithms and programs below one canopy to resolve advanced difficult problems effectively and quickly. These technology emphases on making and implementing methods like cluster processing, parallel processing and distributed processing for resolving difficulties. Parallel processing is a computing method to improve the rate at which the group of data is managed by processing dissimilar parts of the data at the similar time.

✉ R. Dhivya
dhivyarohi@gmail.com

[1] Kingston Engineering College, Vellore, Tamilnadu, India

[2] Vivekananda College of Engineering for Women, Tiruchengode, Tamil Nadu, India

Published online: 22 December 2017

The objective of this hyperspectral imaging is useful in order to determine the range of every pixel in the image of a scene along with the persistence of determining substances, we can easily be detecting procedures. Edge detection, which is a difficult job, in this there are various substances and enormous deviations among them, this creates some difficulties for estimating substances [2]. Edge detection, it is a method of image processing in order to determine the edges in images. Edge detection denotes a particularly significant stage simplifying greater level image examination and hence it persists a space for active examination, along with the continuously developing the new methods. Modern illustrations contain edge sensors by using fuzzy logic, neural networks etc. In this method, we are going to use an algorithm of fuzzy logic. By using this fuzzy logic, we can change the edge thickness simply by changing rules and output parameters. It contains some techniques like attaining, dispensation, examining, and sympathetic images and, in common, high dimensional information as of the actual domain permitted to produce mathematical or symbolic information. In the field of image processing, edge detection contains numerous uses in computer visualization and mechanical visualization [3]. Here we are going to use the method of fuzzy logic in order to find the edges in satellite image.

2 Related works

Bhargavi and Padmavati 2016, suggested a technique of Fuzzy methods permit a novel standpoint to perfect reservations because of the insecurity of gray values which are existing in the images. Earlier several edge detection process has-been suggested for removing the edges in image. This method represents an effective fuzzy edge detection method along with parameters like histogram; by with the help of MATLAB R2015, method of removing noise and threshold are done. Outcome of this system is related with different standard approaches like Sobel, Prewitt and PSO. By using fuzzy logic, we can get the modest and altered fuzzy edge detection. This algorithm improved operative, put on the fuzzy logic toward the value of threshold calculation and using dissimilar thresholds used for the dissimilar image features, and hence develops the detection of edges. Image edge detection is the most significant portion of digital image processing. The edge detection procedure is to classify all edges in a digital image into one of land themes or cover classes. This considered data may be used to make thematic charts of the land cover existing in an image [4]. Important processing speed enhancements have been attained by execution of edge detection approaches on the parallel integrated virtual environment (HIVE) using parallel virtual machine software.

Radhika R Harne and Mohommad Atique 2011 proposed Detection of edges in Digital Images with the help of Fuzzy Logic method and FIS Editor in Matlab. Implementation of this proposed technique is completed with the help of MATLAB of an effective fuzzy logic founded on algorithm in order to identify the input image edges. This suggested method starts with the segmenting the imageries keen on sections by utilizing binary matrix of 2×2. This Fuzzy implication system considered four involvements, which are related to four pixels of immediate perusing medium, single outcome states that, pixel is under reflection of black, white or edge pixel. Rule base includes of sixteen rules [5]. It categorizes the target pixel. The toughness of the suggested technique outcomes for various taken images are correlated and giving an effect in the lines smoothness and straightness for the straight lines.

Ananda krishnan and Santhosh Baboo 2014 proposed a concept of an Assessment of General Edge Detection Methods in Digital Image. In this technique, Edge Detection is the offing theories applied in numerous areas to detect the edges by means of images for learning remedial, organic and other fields. Essentially the image is segmented by means of the four methods such as Smooth out, Improvement, Recognition, and Localization. Edge is a impulsive alteration; it happens in the image. The method of edge Detection is applied in greatest regularly in the segmenting imageries founded on sudden variations in concentration [6]. In this many technique of edge detection like classical developed the derivative procedure in dissimilar bases like Fuzzy Logic, or Neural Networks.

3 Existing methods

3.1 Edge detection using particle swarm optimization (PSO) algorithm

In this PSO, edge detection has been proposed in order to reduce the noise and broken edges. This method offers a novel encrypting system through a new fitness purpose for a PSO algorithm. Hence it is possible to get the best fitting curves of pixels, and these are on an incessant edge. This method is based on the principle that, the curve can distinct into two section [7], hence it maximizes concentration distances among these sections and minimizes the notice distances inside section [8]. This algorithm is useful in every pixel in an image in order to identify the greatest curve, it can be fitted on the ends and permits over a fact in the area of the pixel. And the presentation of this method is verified by smearing three real and one synthetic images, with dissimilar noise stages, and associated through Canny edge detection method. And also this method identifies edges in piercing imageries deprived by means of any preprocessing and post processing processes, like Gaussian filter and method of edge linking [9]. This present kind of this PSO algorithm proceeds a comparatively lengthier period compare to other techniques.

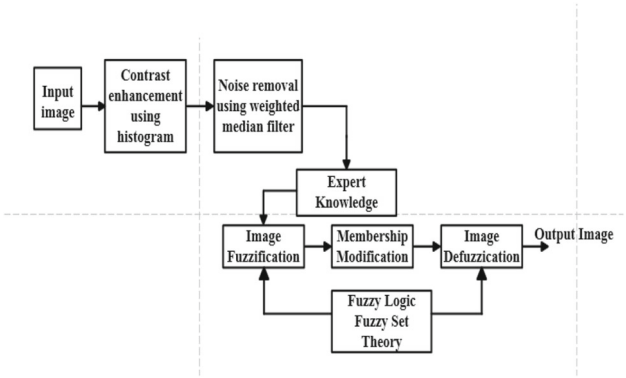


Fig. 1 Block diagram of edge detection using fuzzy logic

3.2 Edge detection using artificial neural network (ANN)

Edge detection, it is one of the important process but relatively hard task in the process of examination and image dispensation. Here the ANN are applied for edge detection founded continuously its adaptive knowledge and nonlinear planning possessions. Fuzzy collections are presented for the period of the exercise stage towards develop the generality capability of neural nets. The presentation of the suggested neural network method in medical images used for the diagnosis of bladder cancer also examined. Effective outcomes of computer reproduction are attained. In this technique, in order to detect the edges of gray scale images, a multi-layer forage advancing neural network is used. Unlike the multiple neural network methods, here only a single neural network is used for edge detection. In this investigation ANN are effectively useful in order to identify edges in the images of gray-scale images [10]. In the upcoming days also it helps to develop the neural network edge detector.

Compare to PSO and neural network methods, the technique of edge detection using the algorithm of Fuzzy logic is better [11]. Hence, we are to introduce this technique as a proposed method.

4 Proposed technique

In this fuzzy logic method, the input image is taken from the remote sensing image.

4.1 Contrast enhancement using Histogram equalization

Histogram equalization (HE) is an indirect contrast improvement technique, the image of histogram is altered. Since, stretching the global circulation of the intensity, the information placed on the histogram or probability distribution function (PDF) of the image will be gone. To avoid this drawback, HE method uses the Bi-histogram equalization methods for stabilizing the intensity and improve differences of the image considerably, methods of Multi histogram equalization are used in order to achieve by means of virtuous intensity stabilizing devoid of presenting slightly unwanted artefacts, as shown in Fig. 1. Clipping histogram equalization approaches are greater in regulate the augmentation amount, intensity preservative then eluding over intensification of noise in the image.

In the method of histogram equalization, the improvement rate is related to the rate of increasing thickness purpose c(x). limit the rate of improvement rate through preventing the values of p(x).

$$\frac{dc(x)}{dx} = p(x)$$

Difference of image is significantly improved by the Suitable value of plateau threshold value. T is chosen as a value of threshold in the method of plateau histogram equalization and anywhere the value P(K), histogram of an image is more than T, at that time this value is moved to equivalent T, or else it is unmovable. The plateau histogram of an image $P_T(k)$, which is given by,

$$P_T(k) \begin{cases} P(k) & P(k) \le T, \\ T, & P(k) > T, \end{cases}$$

where, 'k' signifies the image of gray level, 0 k 255 for 8-bit data. At that time, the cumulative histogram of an image is given by,

$$F_T(k) = \sum_{j=0}^{k} P_T(j) \quad 0 \le k \le 255$$

$$D_T(k) = \left\lfloor \frac{255.F_T(k)}{F_T(255)} \right\rfloor$$

where $D_T(k)$is the value of 'k' when improvement and Ŋŋ signifies truncation to the following lesser integer.

4.2 Noise removal using median filter

The median filter, which is a nonlinear signal dispensation method founded on statistics. The value of digital image noise or the arrangement is substituted through the value of the median in the near area. The output of median filter process is the real appearance and the output image individually, where W represents the two-dimensional mask. The size of the mask is nu n like 3u 3, 5u 5 etc. The median filter is a nonlinear, hence its mathematical examination is relatively challenging intended for the image through casual noise [12]. The variation of noise in the median filtering is given by,

$$\sigma_{med}^2 = \frac{1}{4nf^2\overline{(n)}} \approx \frac{\sigma_i^2}{n + \left(\frac{\pi}{2}\right) - 1}\frac{\pi}{2} \tag{1}$$

And it is for an image with zero mean noise below standard circulation.

where power of noise input is given by V2 i and n represents the median filtering mask size. And the noise density in the utility is given by nf and the variation of noise in the average filtering is given as follows,

$$\sigma_0^2 = \frac{1}{n}\sigma_i^2 \tag{2}$$

By equating the equations (1) and (2), the effects of median filtering rely on two belongings, such as 1. size of the mask, and 2. the circulation of the noise. Compare to average filtering, the performance of median filtering of casual noise decrease is improved. primarily the mask of filtering is u nn quadrangular mask. n is usually additional by seeing of the regularity of the mask. If the mask is smaller, then the better image details are recollected. Or if the mask is larger, then the noise presentation is weaker, less image details are recollected and the performance of noise is stronger [13]. In order to solve the ambiguity, we present the adaptive filtering algorithm. In this procedure, rendering to noise levels of the mask this algorithm can be able to resize the mask adaptively. Adaptive filtering involves two stages; such as Stage 1—resizing of mask adaptively. In this, (a) Initialization—let n 3; (b) Computation—1 medA min, 2 medA max (c) Judgment—if A! 01 and A 02, after this on stage 2—if not on means, at that time increase the mask size, let nn 2 and turn to (2). Since the average filter consumes enhanced presentation used for casual noise filtering, we associate the median filter along with the average filter to assured filtering mask size. The developed technique can decrease noises and keep the image particulars superior.

4.3 K-means clustering

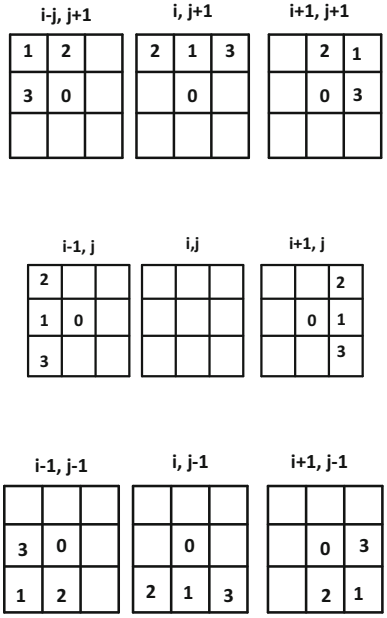
K-means clustering is used to identify the edges in the images, this k means algorithm starts by the initialization of a mean vector repetition. K-means is useful in the image in order to combine the parallel pixels. This method is very faster, in K-means, k no of clusters produced from the input images. It is identified for every K clusters. Next coming to the second step, in this, the pixel vector is contiguous to the mean vector is identified, depending upon every pixel of the training set is allocated to that class. After, this pixel set customs the first set of result limitations. As of this set of result limitations, an innovative set of cluster mean vector is calculated and once again this pixel is reallocated consequently. Afterward every repetition k- means becomes inclined to attentions of data in nearby areas of the feature space [14]. This procedure recurrence till around there is no important alteration in pixel tasks moving from one cluster to another. Finally, the position of each cluster centroids has no longer become alternate the clusters are said to be constant and the process of clustering method ended and we determine the values of threshold from the last calculated value of centroid.

4.4 Edge detection using fuzzy

Fuzzy logic, it is a method of first-order logic. Where it permits the certainty of a declaration to be signified as a value between 0 and 1, rather than simply True (1) or False (0). In order to accomplish the method of image processing by fuzzy logic, 3 phases need to be happen. First is image fuzzification, which is used to alter the values of membership of an exact data set or image. After the transformation of image data from gray-level flat towards the association flat by using fuzzification, suitable fuzzy methods alter the membership values [15]. This is a fuzzy clustering base on fuzzy rule method. The process of decoding the results, which is called defuzzification, then results in an output image. The foremost influence of fuzzy image method is in the alteration of the fuzzy membership values". Concept fuzzy set offers us influential device in order to signify and progress the human understanding in the method of fuzzy if then- rules. The image of fuzzy field is denoted by IF(x,y). The fuzzy image is managed by the operators of fuzzy set £ yielding a new fuzzy image IF(x,y)'. Finally,the fuzzy image is mapped back to the original domain through the de-fuzzification function D. In the original field the processed image is characterized by I(x,y)':

$$F : I(X, Y) \Longrightarrow I_F(X, Y)$$
$$£\,[I_F(X, Y)] \Longrightarrow I'_F(X, Y)$$
$$\mathrm{D} : I_F(X, Y) \Longrightarrow I'(X, Y)$$

4.4.1 Fuzzy rules



In this algorithm is established on the domination of nine pixels set, and it is a portion of a 3 × 3 space of an image toward fuzzy set disorders, it helps to highpoint every edges, which are accompanying by means of an appearance. This fuzzy conditions support in order to check the comparative pixel values; it can be existing in case of existence on an edge. Hence the comparative values of pixel are involved in removing completely edges which are accompanying in an image.

4.4.2 Peak signal to noise ratio (PSNR)

Consider, X(i, j) is image source and it includes M by N pixels. Let Y (i, j) is reconstructed image. And it is reassembled through make out the encoded form of X(i, j). The mean square error (MSE) of the image is calculated by

$$\text{MSE} = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} [X(i,j) - Y(i,j)]^2}{MXN}$$

PSNR value is calculated by

$\text{PSNR} = 20\,log_{10}\left[\frac{\max(Y(i,j))}{RMSE}\right]$ Where RMSE indicates reconstructed mean square error. In this technique we are using PSNR values, because if the PSNR value is high means it enhances the contrast of image.

Simulation results

The above Fig. 2 shows the input image for edge detection

The above Fig. 3 shows the result of contrast enhanced image.

In this contrast enhanced image, the adaptive cryptogram equalization method is applied to increase the quality of image since after eliminating the noise, image quality develops slightly fewer. Thus, to overcome this effect, we used method of cryptogram equalization. This technique increases the superiority of image then clearly the contrast image also improved.

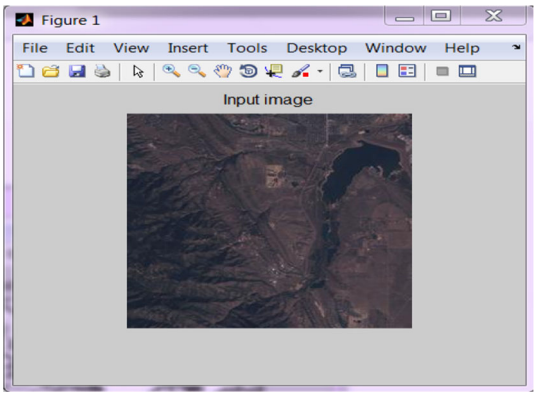


Fig. 2 Input image

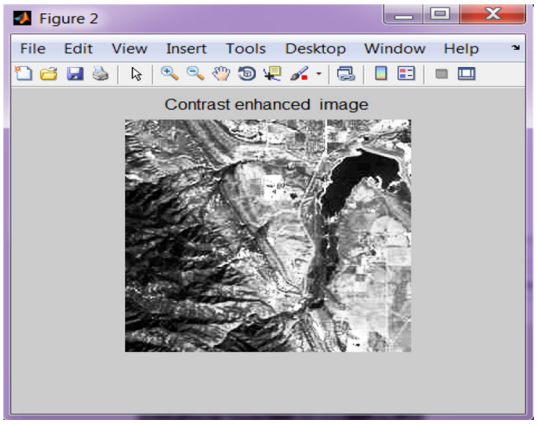


Fig. 3 Contrast enhanced image

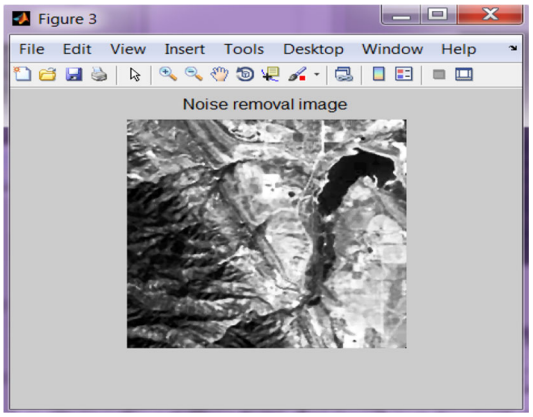


Fig. 4 Noise removable image

The above Fig. 4 shows the noise removal image.

To remove the noise, it is necessary to add additional noise. Adopted median filter method is used in order to eliminate

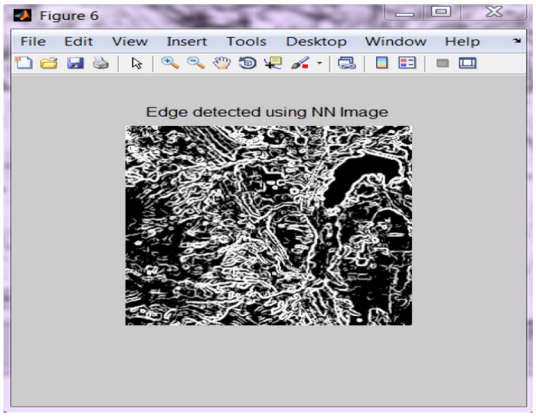


Fig. 5 Edge detected using NN image

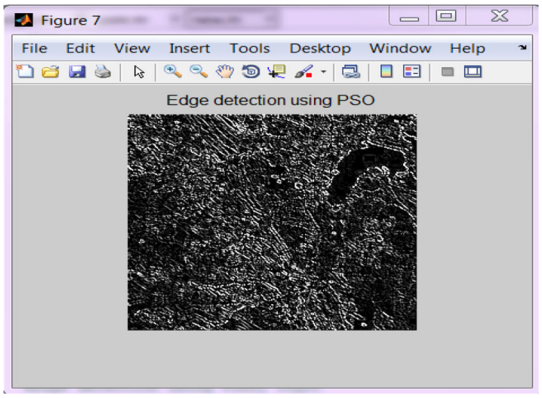


Fig. 6 Edge detected using PSO image

this noise. In phrase of fringe preservation and removal of noise, related to improved images in the alternating filters our improved images signify a significant improvement. This proposed system eliminates the salt-and-pepper-noise in the noise level.

The above Fig. 5 shows the edge detected image using neural network method.

The above Fig. 6 shows the edge detected image using PSO method.

The above Fig. 7 shows the output image of proposed technique, Fuzzy logic.

Compare to output images of neural network and PSO techniques, the outputs of fuzzy logic techniques are better and cleared. It gives permanent effect in the lines smoothness and straightness for the straight lines and good roundness for the curved lines. And sharpness in the curves as shown in the above examples.

The mean square error (MSE) value of the existing neural network is 0.2125 and MSE for PSO logic is 0.2135, but in our proposed fuzzy method, MSE value is 0.1329. Compare to PSO and neural network, it is better. Similarly, Peak signal to noise ratio (PSNR) value of the existing neural network method is 54.8564 and also PSNR value of existing PSO

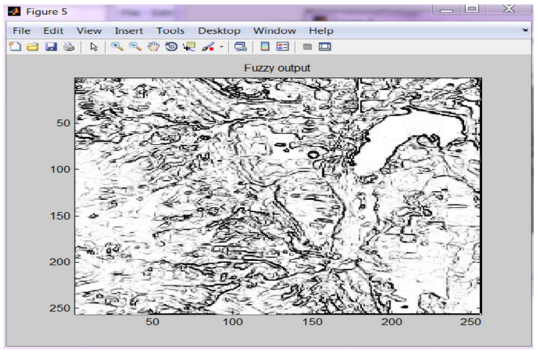


Fig. 7 Fuzzy output image

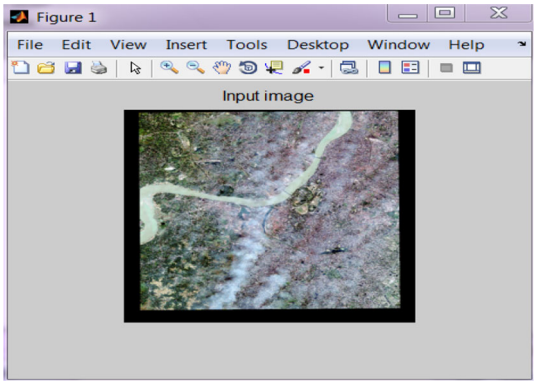


Fig. 8 Input image

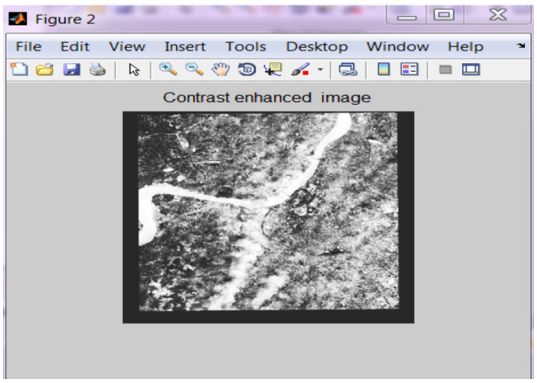


Fig. 9 Contrast enhanced image

logic is 54.8370, but in this proposed fuzzy logic method PSNR value is 56.8949.

Similarly, another example for comparing neural, PSO and fuzzy method as shown below.

The above Fig. 8 shows the input image for edge detection

The above Fig. 9 shows the result of contrast enhanced imaged

The above Fig. 10 shows the image of noise removal image.

The above Fig. 11 shows the edge detected image using neural network method.

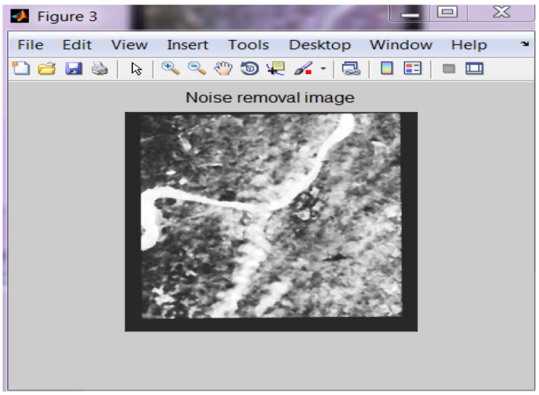


Fig. 10 Noise Removal image

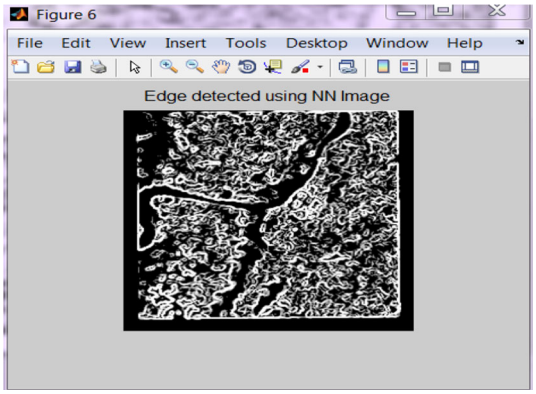


Fig. 11 Edge detected using NN image

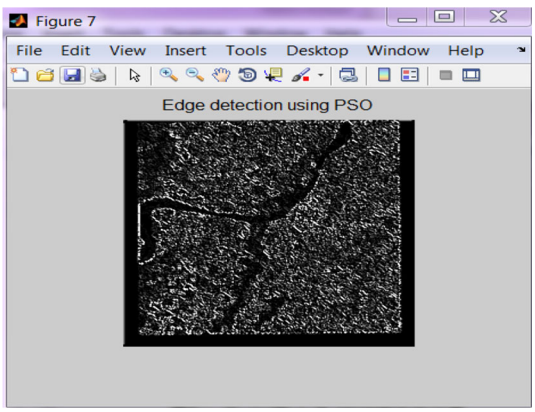


Fig. 12 Edge detected using PSO

The above Fig. 12 shows the edge detected image using PSO method.

The above Fig. 13 shows the output image of proposed fuzzy logic technique.

The MSC value of the existing neural network is 0.2124 and The MSC value of the existing PSO logic is 0.2136, but in our proposed method, MSE value of fuzzy logic is 0.1369. Compare to neural network and PSO method, fuzzy logic method is better.

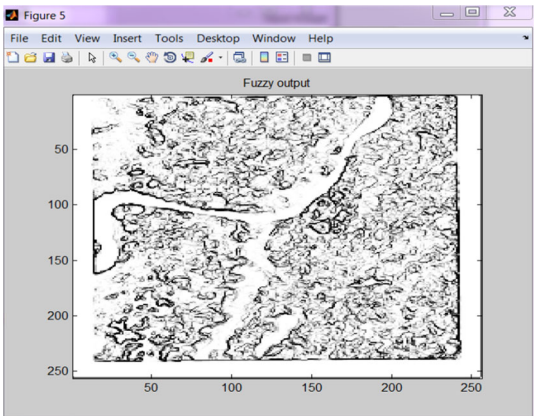


Fig. 13 Output image of Fuzzy method

Table 1 Comparison of MSE and PSNR values

	Example 1 (Fig. 2)		Example 2 (Fig. 8)	
Techniques	MSE	PSNR	MSE	PSNR
Neural network (NN)	0.2125	54.8564	0.2124	54.8585
Particle swarm optimization (PSO)	0.2135	54.8370	0.2136	54.8357
Fuzzy technique (proposed)	0.1329	56.8949	0.1369	56.7671

Similarly, PSNR value of the existing neural network method is 54.8585 and PSO logic is 54.8357, but in this proposed fuzzy logic method PSNR value is 56.7671. Compare to NN and PSO method, Fuzzy logic technique is better.

From the above table it is clear that, the proposed technique gives better results than NN and PSO techniques.

5 Conclusions

In this proposed technique, plateau histogram equalization is used in order to improve the contrast enhancement in satellite images. The foremost aim of this method is to provide a permanent effect in the lines smoothness and straightness for the straight lines and good roundness for the curved lines. And sharpness in the curves. This new method is improved successfully and tested in satellite images. And the results of this method are compared with existing methods using PSNR and MSE values. We got good contrast enhancement without any noise. In this adaptive filtering is used in order to remove the noise. And it gives good PSNR and MSE values compared to existing techniques, as shown in Table 1. This technique is simple hence it is easy to develop, and it can be used in the application of real time system. Finally, by using these techniques we got output image with smooth lines, straight edges and roundness in the curved lines permanently.

6 Future scope

In future work, Further the size of mask can be improved from 2 × 2 to 3 × 3 or 4 × 4 and hence additional directions can be set and possible to get better results regarding of mask size. This technique can be implemented with the modified version of other techniques to get better result. By using improved optimization techniques, we can better result in edge thickness.

References

1. Verma, O.P., Parihar, A.S.: An optimal fuzzy system for edge detection in color images using bacterial foraging algorithm. IEEE Trans. Fuzzy Syst. **25**(1), 114–127 (2017)
2. Solanki, C., Godfrey, W.W.: Technique for edge detection based on interval Type-2 fuzzy logic with sobel filtering. In: International Conference on Information Science (ICIS), pp. 38–43 (2016)
3. Patel, D.K., More, S.A.: Technique by fuzzy logic and cellular learning automata using fuzzy image processing. In: International Conference on Computer Communication and Informatics, pp. 1–6 (2013)
4. Kumar, E.B., Sundaresan, M.: Edge detection using trapezoidal membership function based on fuzzy's mamdani inference system. In: International Conference on Computing for Sustainable Global Development (INDIACom), pp. 515–518 (2014)
5. Sarakon, P., Charoensiriwath, S., Uyyanonvara, B., Kaneko, H.: 3D body shape clustering based on PSO by multi-fitness function. In: IEEE Conference on Knowledge and Smart Technology (KST), pp. 34–39 (2017)
6. Kumar, V., Lal, T., Dhuliya, P., Pant, D.: A study and comparison of different image segmentation algorithms. In: 2nd International Conference on Advances in Computing, Communication, & Automation (ICACCA), pp. 1–6 (2016)
7. Gautam, D., Ahmed, M.: Efficient fuzzy edge detection using successive Otsu's method. In: International Conference for Convergence for Technology, pp. 1–5 (2014)
8. Wulder, M.A., White, J.C., Goward, S.N., Masek, J.G., Irons, J.R., Herold, M., Cohen, W.B., Loveland, T.R., Woodcock, C.E.: Landsat continuity: issues and opportunities for land cover monitoring. Remote Sens. Environ. **112**, 955–969 (2008)
9. Fergani, B., Kholladi, M.K.: A discrete particle swarm optimization algorithm for geographical map contour reconstruction. In: IEEE Conference on Digital Information and Communication Technology and its Applications (DICTAP), pp. 142–144 (2016)
10. Chen, L., Ma, Y., Liu, P., Wei, J., Jie, W., He, J.: A review of parallel computing for large-scale remote sensing image mosaicking. Clust. Comput. **18**(2), 517–529 (2015)
11. Chinnasamy, S.: Performance improvement of fuzzy-based algorithms for medical imageretrieval. IET Image Process. **8**(6), 319–326 (2014)
12. Mathur, N., Dadheech, P., Gupta, M.K.: The K-means Clustering based fuzzy edge detection technique on MRI images. Fifth International Conference on Advances in Computing and Communications (ICACC), pp. 330–333 (2015)
13. Melin, P., Gonzalez, C.I., Castro, J.R., Mendoza, O., Castillo, O.: Edge-detection method for image processing based on generalized type-2 fuzzy logic. IEEE Trans. Fuzzy Syst. **22**(6), 1515–1525 (2014)
14. Codizar, A.L., Solano, G.: Plant leaf recognition by venation and shape using artificial neural networks. In: International Conference on Information, Intelligence, Systems & Applications (IISA), pp. 1–4 (2016)
15. Homer, C.G., Ramsey, R.D., Edwards, T.C., Falconer, A.: Landscape cover-type modeling using a multi-scene thematic mapper mosaic. Photogramm. Eng. Rem. S. **63**, 59–67 (1997)



R. Dhivya received the B.E. degree from Bharathidasan College of Engineering, affiliated to Anna University, Chennai. Tamilnadu, India in 2008 and the M.E. degree from C. Abdul Hakeem College of Engineering and Technology affiliated to Anna University, Chennai, India, in 2011. She is currently working towards her doctoral degree at Anna University, Chennai, India, since 2015. She has authored over ten research publications in International and National journals and conferences. Her research interests include image processing, Fuzzy logic and neural network.



R. Prakash received the B.E. degree from Government College of Technology, affiliated to Bharathiyar University, Coimbatore. Tamilnadu, India in 2000 and the MTech degree from the College of Engineering, Thiruvananthapuram, Kerala, India, in 2003. He obtained his Ph.D. degree in Electrical and Electronics Engineering from Anna University, Chennai, India, in 2012. At present, he is working as Professor / R & D. He has authored over forty-five research Publication in international and national journals and conferences. His area of interest includes adaptive control, Fuzzy logic, Neural network and control system.