

Dimensionality Reduction using Bi-Dimensional Empirical Mode Decomposition Method for Hyperspectral Image Segmentation



B.Raviteja, K.Venkata Rao

Abstract: This paper presents a dimensionality reduction of hyperspectral dataset using bi-dimensional empirical mode decomposition (BEMD). This reduction method is used in a process for segmentation of hyperspectral data. Hyperspectral data contains multiple narrow bands conveying both spectral and spatial information of a scene. Analysis of this kind of data is done in three sequential stages, dimensionality reduction, fusion and segmentation. The method presented in this paper mainly focus on the dimensionality reduction step using BEMD, fusion is carried out using hierarchical fusion method and the segmentation is carried out using Clustering algorithms. This dimensionality reduction removes less informative bands in the data set, decreasing the storage and processing load in further steps in analysis of data. The qualitative and quantitative analysis shows that best informative bands are selected using proposed method which gets high quality segmented image using FCM.

Keywords: Bidimensional empirical Mode Decomposition, Fuzzy C-means, Hyperspectral Imaging

I. INTRODUCTION

The Mechanism of getting information on earth without physical contact through satellites is called remote sensing. The passive sensors are used to read the signal reflected from the earth's surface [1]. With this signal, the remote sensing image is generated. The main task in analysing the remote sensing image is segmentation. Ordinary cameras generate images with spectral resolution but not having spatial information. With the invent of hyperspectral technology, images with both spatial and spectral information are generated [2]. To generate a hyperspectral dataset, spectrometers are used with wavelengths ranging from visible region to near infrared region. The hyperspectral dataset consists of multiple bands, with each band is generated by specific wavelength.

The pixels in each band gives spectral information and number of bands in the dataset gives spatial information. Hyperspectral image segmentation is new research area, in which efficient algorithms to be designed in segmenting the data set [3].

This paper presents a mechanism in segmenting the hyperspectral dataset. The first step in analysing the hyperspectral data is to reduce the dimensionality of data. Reduction in dimensionality means removing bands in the dataset which is having less or redundant information. Dimensionality reduction can be done using value based and feature based methods. Feature based methods are less efficient than value-based methods. In this paper, Bi-dimensional Empirical Mode Decomposition is used for dimensionality reduction [4]. This reduction will decrease many requirements for processing hyperspectral dataset such as storage and computational load. After reduction, the images are fused into a single image using hierarchical image fusion technique. This fused image is segmented using clustering algorithm such as k-means, k-medoids and Fuzzy c-means [5]. Out of these clustering algorithms, Fuzzy c-means is used in this paper as it generates better accuracy in segmented result. Accuracy in segmentation is measured using Mean Square Error (MSE) parameter [6]. The flow diagram of proposed framework is shown in figure 1. Section 2 presents BEMD based dimensionality reduction method, Section 3 Hierarchical Image Fusion, Section 4 algorithm for segmentation and Section 5 presents Conclusions.

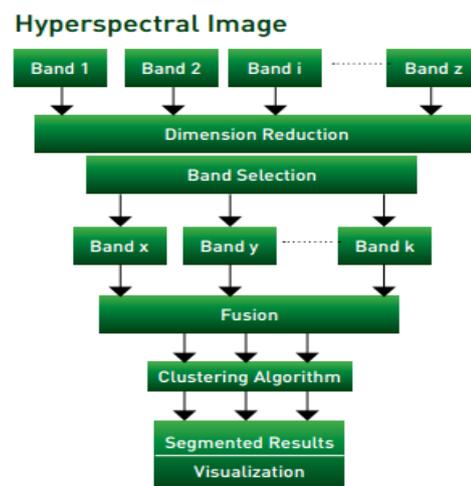


Fig 1: Framework for hyperspectral image segmentation

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II. DIMENSIONALITY REDUCTION USING EMD

Empirical Mode Decomposition is a method [7] which decomposes any 1-D waveform into many functions called intrinsic mode functions (IMF) and the last IMF is called residue. These IMFs have the property that combining IMFs and residue gives the original signal. Each IMF have two properties related to number of extrema points and number of zero crossings. This process of getting IMFs from any 1-D waveform is called shifting process. The same process can be extended to two dimensional that is an image. This process is presented below in figure 2.

Each IMF generated using BEMD process gives intrinsic information having different features. In the process of band selection, we create band subsets using Band Correlation (BS) as a measurement function to estimate the quality of bands. These band subsets preserve the valuable information from the input data. This information in the band subsets provide better segmentation results with low redundancy. The process of band selection is shown in figure 3. The Band Correlation (BC) can be calculated by:

$$BC(i, j) = \frac{\sum_{p=1}^{N_b} (x_{ip} - \mu_i) \cdot (x_{jp} - \mu_j)}{\sqrt{\sum_{p=1}^{N_b} (x_{ip} - \mu_i)^2} \cdot \sqrt{\sum_{p=1}^{N_b} (x_{jp} - \mu_j)^2}}$$

The mechanism for band selection using BEMD with BC as quality parameter is shown below:

1. First set $B = \{ \}$. Select the band from the input data having high entropy value and add it to B.
2. Then select other band into this set B, by calculating BC between selected band and existing band.
3. If the selected band has largest BC value, add the IMFs of the selected band.
4. This process is repeated until required bands are selected.
5. Different IMFs have different features, we combine these band subsets into a band combination, which contains all intrinsic information of the input data.

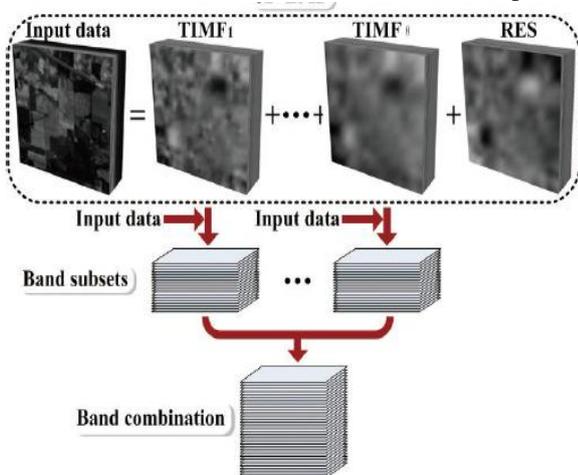


Fig 3: Band Selection using BEMD

III. HIERARCHICAL IMAGE FUSION TECHNIQUE

The hierarchical fusion method combines the set of images in a hierarchical fashion. It first decomposes the original set of images into k subsets [8]. The number of images in each subset is equal to p, where the minimum value of p is 10. The images in these k subsets are fused to generate p images. Again, these p images are divided into subsets, and again fusion takes place in each subset. This process continues in hierarchical fashion until a single image is generated, where the last level of fusion contains only two images. The fusion at each step is done linearly, means adding all images and dividing with weights [10]. The flow diagram of hierarchical image fusion is shown in figure 4.

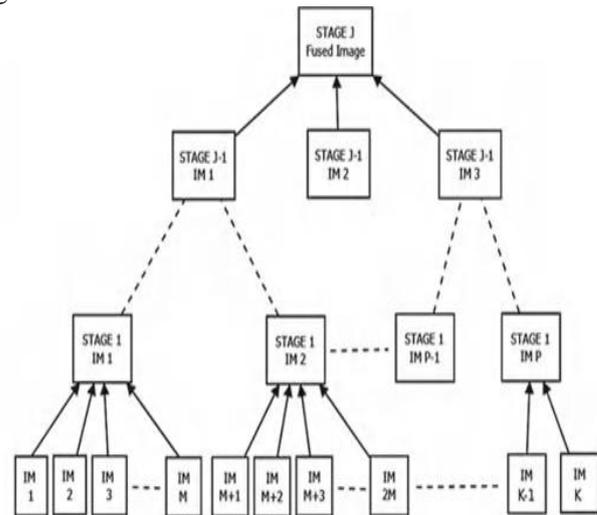


Fig 4: Hierarchical Image Fusion

IV. CLUSTERING ALGORITHMS

The flow diagram of k-means clustering [7] algorithm is shown in figure 5.

The flow process of Fuzzy C-Means Algorithm [7] is shown in figure 6. The flow process of K-Medoids Algorithm [9] is shown in figure 7.

V. EXPERIMENTAL RESULTS

The qualitative and quantitative analysis of methodology presented in this paper is done on Pavia University data set collected from [8] which contains 103 spectral bands. BEMD based algorithm presented in this paper is used for dimensionality reduction. After reduction, only 43 bands from 103 bands are selected. Using hierarchical fusion, these 43 bands are fused into single image. This image is segmented using FCM algorithm. The quantitative analysis is measured using MSE defined in [11]. The qualitative analysis of the proposed method on Pavia University hyperspectral data set is shown in figure 8. Table 1 shows the quantitative evaluations of three clustering algorithms after segmenting the hyperspectral image.

Table 1: Quantitative analysis of proposed methodology

| dimensionality reduction algorithms | MSE Values by FCM algorithm |
|-------------------------------------|-----------------------------|
| Entropy | 212.8 |
| SAM | 192.4 |
| BC | 182.6 |
| BEMD + BC | 179.8 |

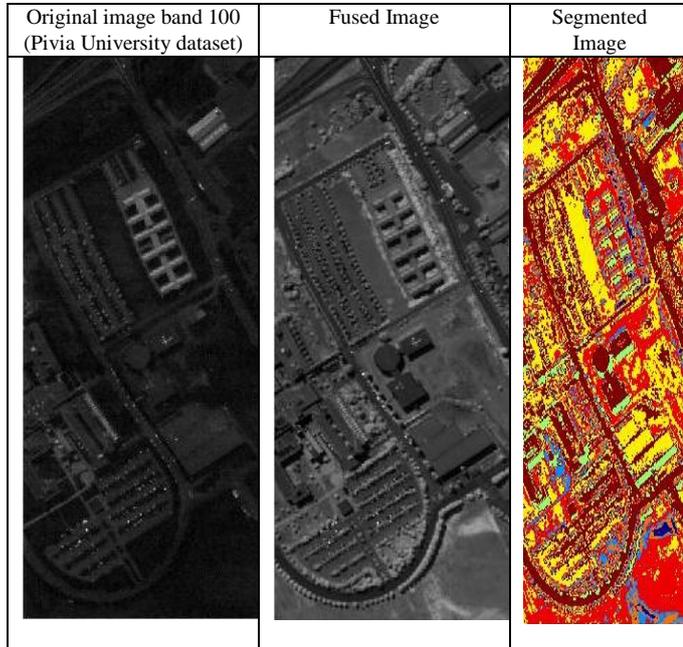


Figure 8: Segmentation of hyperspectral image using FCM

VI. CONCLUSIONS

In this paper a methodology for dimensionality reduction in framework for hyperspectral image segmentation is presented. The analysis of hyperspectral data is done three stages, dimensionality reduction, fusion and segmentation. In this paper BEMD concept is used for dimensionality reduction with BC as parameter in BEMD process for band selection. The informative bands are selected using the methodology presented in paper. These informative bands are fused to get a single image and this single image is used for segmentation. The segmentation result will give the information about the hyperspectral dataset by considering most useful bands in the data. This dimensionality reduction process leaves the redundant data and increases the segmentation result accuracy. The methodology presented in this paper shows the performance of FCM algorithm by using different similarity metrics in dimensionality reduction algorithm.

REFERENCES

1. Yi Ma, Jie Zhang and Yufeng Gao, " High Resolution Remote Sensing Image Classification of Coastal Zone and its Automatic Realization", Proceedings of IEEE International Conference on Computer Science and Software Engineering, 2008, 827-829.
2. B.Saichandana et.al. "Hyperspectral Image Enhancement Using Evolutionary Algorithm" International Journal of Advanced Research, March 2016; 3(4): 934-938.

3. B.RaviTeja, J.Harikiran et.al. "A Framework for Hyperspectral Image Segmentation using Unsupervised Algorithm", Indian Journal of Science and Technology, December 2016; 9(47): 1-6.
4. B.Raviteja, et.al., "A New Methodology of Hierarchical Image Fusion in Framework for Hyperspectral Image Segmentation", Indonesian Journal of Electrical engineering and Computer Science, Volume 6, Number 1, pp. 58-65, April 2017.
5. Adolfo Martinez Uso et.al. "Clustering based Hyperspectral Band Selection using Information Measures", IEEE Transactions on Geoscience and Remote Sensing, Vol 45, No 12, December 2007.
6. Parul Shah et.al. "Efficient Hierarchical Fusion using Adaptive Grouping Techniques for Visualization of Hyperspectral Images", Proceedings of ICICS IEEE 2011.
7. J.Harikiran, P.V.Lakshmi et.al. "Multiple Feature Fuzzy C-means Clustering Algorithm for Segmentation of Microarray image", IAES International Journal of Electrical and Computer Engineering", 2015; 5(5): 1045-1053.
8. http://www.ehu.eus/cwintco/index.php?title=Hyperspectral_Remote_Sensing_Scenes.
9. B.Saichandana, R.Kiran kumar et.al, "Clustering Algorithm combined with Hill climbing for Classification of Remote Sensing Image", IAES International Journal of Electrical and Computer Engineering, 2014; 4(6): 923-930.
10. Ketan Kotwal, et.al. "Visualization of Hyperspectral Images Using Bilateral Filtering", IEEE transactions of Geoscience and remote Sensing, 2010; 48(5): 2308-2319.
11. Nor Ashidi Mat Isa, Samy A.Salamah, Umi Kalthum Ngah (2012), "Adaptive Fuzzy Moving K-means Clustering Algorithm for Image Segmentation", IEEE Transactions on Consumer Electronics, 2010; 55(4): 2145-2153.
12. Ozan Arslan et.al. "A Comparative analysis of Classification methods for hyperspectral images generated with conventional dimension reduction methods", Turkish Journal of Electrical Engineering and Computer Sciences, (2017), 25:58-72.

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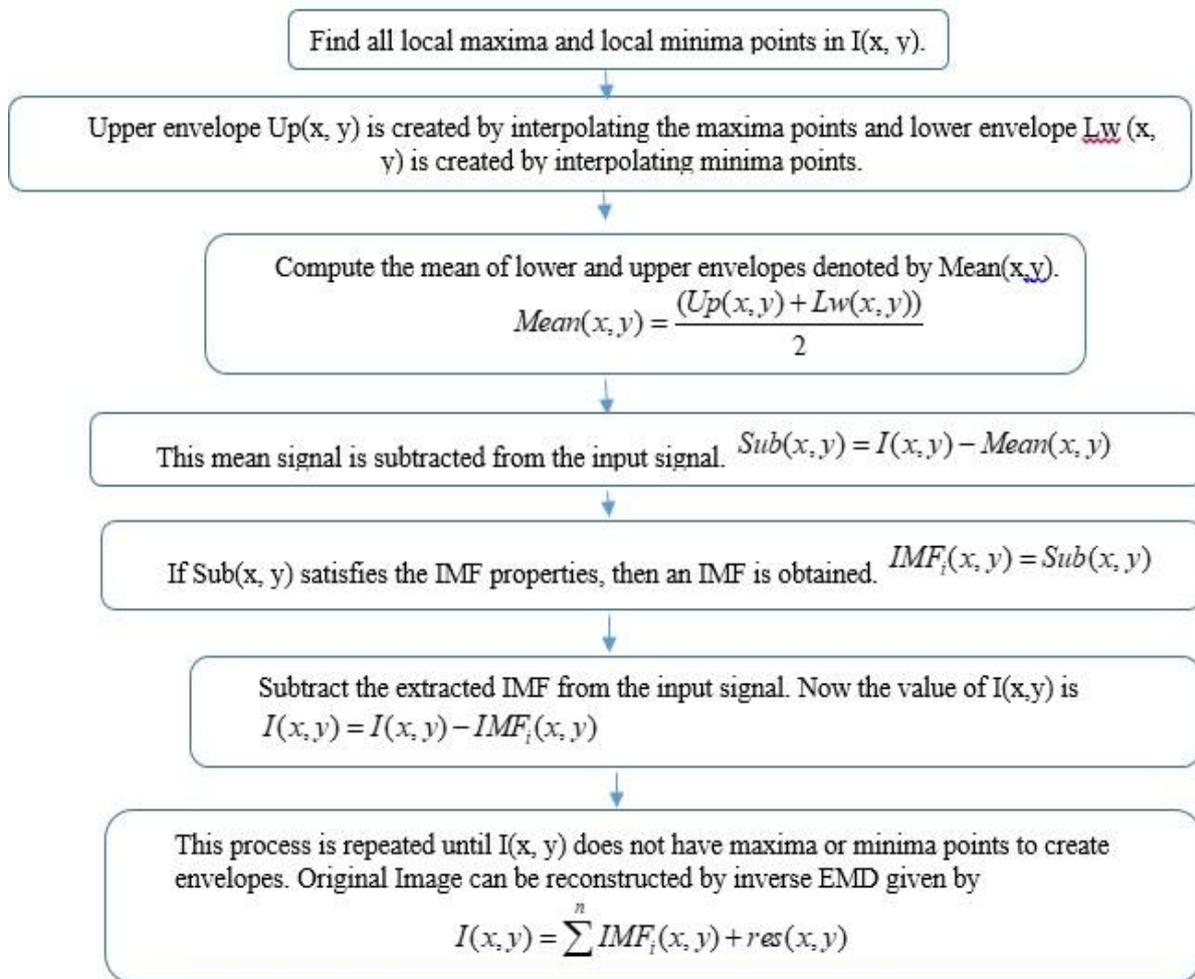


Fig 2: Bi-dimensional Empirical Mode Decomposition process

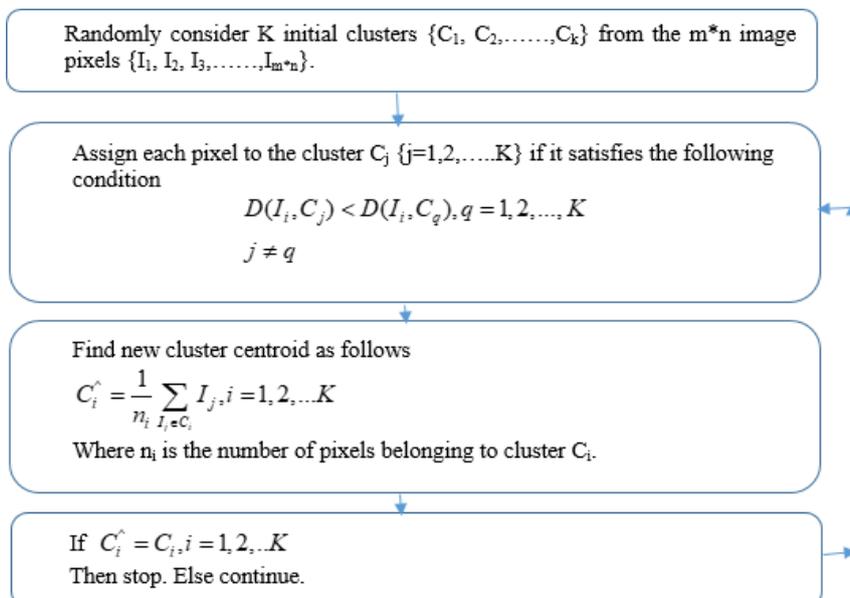


Fig 3: K-means clustering algorithm

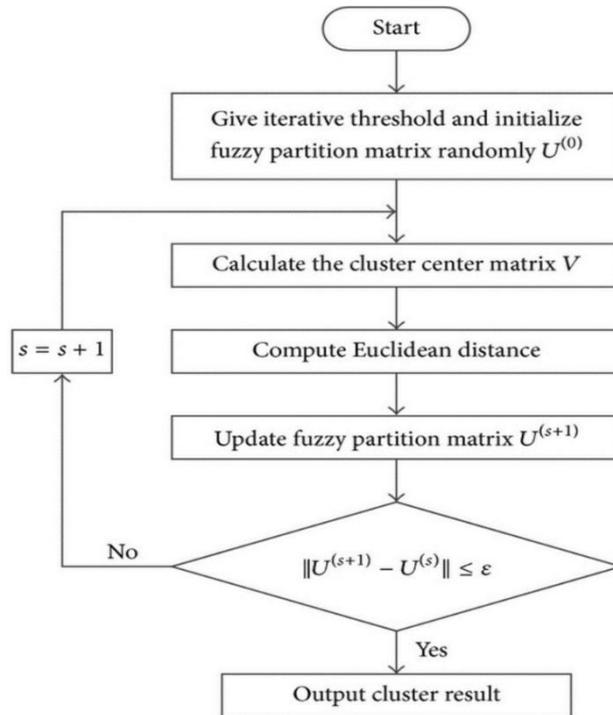


Fig 6: FCM algorithm

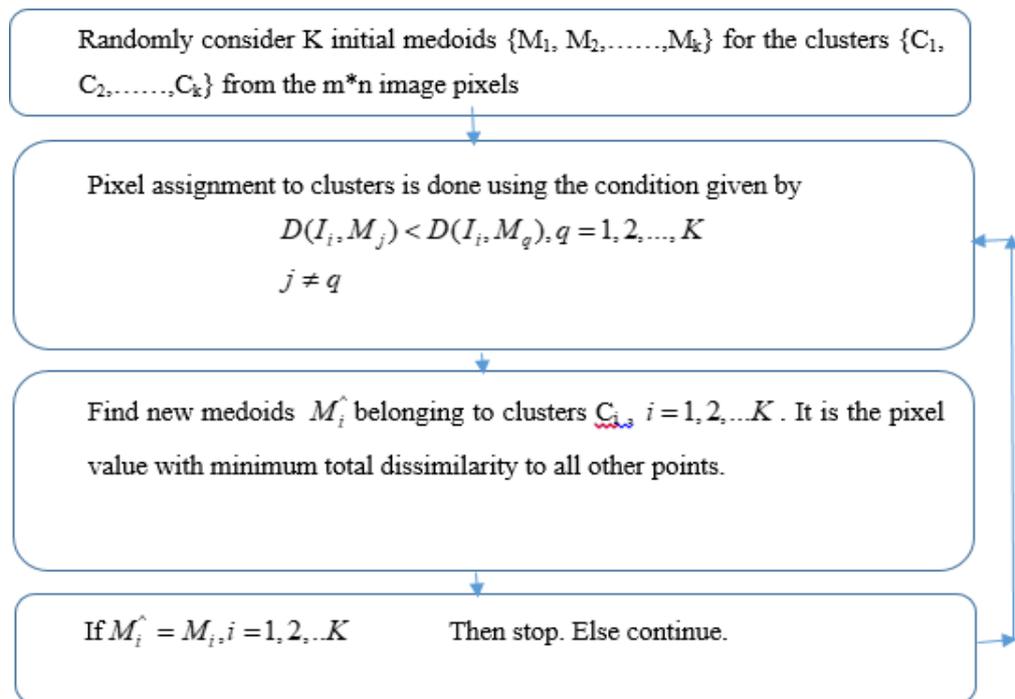


Fig 7: K-medoids Algorithm