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A Survey of Hyper Spectral Image Segmentation Techniques for Multiband Reduction

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ABSTRACT

Image segmentation is to stratify or cluster an image into manifold parts according to the attribute of the image. It incorporates segregation an image into its integral parts and isolates these parts of objects. A great concoction of segmentation algorithms has been flourished in the last decades. Image segmentation can be categorized into four sundry types encompassing histogram thresholding based methods, clustering based methods, texture analysis based methods and region based split and merging methods. Now-a-days, the hyper-spectral image segmentation in multiband image is the prerequisite of the hour. There are plethora clustering algorithms operated on these images on which K-Means is a general panacea to the segmentation of multi-dimensional data. In this survey, disparity segmentation techniques for multi band image segmentation are discussed. Besides, inter and intra band clustering method on these images are also debated and illustrated.

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INTRODUCTION

Ostensibly, segmentation is a process of partitioning an image space into some consequential homogeneous regions. The prosperity of an image analysis system depends on the essence of segmentation. The intent of clustering is to arbitrate the inherent grouping in a set of unlabeled data. Clustering methods are viewing an image as a set of multi-dimensional data and classifying the image into disparate parts according to certain homogeneity criterion. Multiband segmentation is based on the segmentation of subsets of bands using multi-thresholding followed by the fusion of the resulting segmentation channels. The grayscale pixel values are multidimensional in multiband images. Multiband images encompass the case of color images with bands correlated with red, green and blue colors or a monumental alternative color formatting patterns. Multiband images are also indicated to as multispectral or multichannel or hyperspectral images. Multiband images are also broached to as multispectral or multichannel or hyperspectral images.

Apparently, clustering is a process for codifying objects or patterns in such a way that samples of the same group are more similar to one another than samples belonging to miscellaneous groups. Multitudinous clustering strategies have been used, such as the hard clustering scheme and the fuzzy clustering scheme, each of which has its own special characteristics.

Obviously, the newfangled approach is based on the K-Means algorithm and it conquers the constraint of having to specify the number of clusters by consolidating a validity measure based on the intra-cluster and inter-cluster distance measures. K-Means is an iterative approach that is used to segregate the hyper-spectral feature matrix into K clusters. K-Means is one of the smooth unsupervised learning algorithms to solve the well-known clustering problem. Since, the K-Means algorithm endeavors to shrink the average intra-cluster distance; it is plausibly that the cluster having mountaintop variance will be dissociated by the k-means procedure when the number of clusters is escalated.

Superficially, Image segmentation algorithm based on FCM is a paramount one in the image segmentation field and it has been used immensely. FCM is one of the most used methods for image segmentation and its success chiefly attributes to the introduction of fuzziness for the belonging of each image pixels. FCM is an iterative approach that is used to segregate the hyper-spectral feature matrix into membership levels. In FCM clustering, data items can apply to more than one cluster and

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correlated with each element is a set of partnership levels. Fuzzy clustering is an action of assigning these partnership levels and then using them to select data items to one or more clusters. Image classification algorithms can be grouped into two main classes, namely supervised and unsupervised. Particle Swarm Optimization (PSO) is a population based search process where individuals, indicated to as particles, are grouped into a swarm. Each particle in the swarm describes a candidate solution to the optimization obstacle.

Speciously, the paper is organized as follows. Section 2 describes inter band, intra band, FCM, K-Means clustering for multiband image segmentation. Section 3 Illustrate results and discussion. Section 4 provides conclusion and future enhancement.

1. Inter And Intra Band Clustering Multiband Image Segmentation:

A) Image Segmentation:

Professedly, Image segmentation (T.-W. Chen, *et al.*, 2008) is one of the paramount and most significant tasks in image analysis and computer vision. Segmentation can be elucidated as an intensive partitioning of the input image into regions, each of which is examined to be homogeneous with respect to some criterion of interest. The objective of segmentation is to find regions that exemplify objects or consequential parts of objects. Image segmentation is useful in multifarious applications. It can describe the regions of interest in a scene or annotate the data. The existing segmentation algorithms are categorized into region based segmentation, data clustering and edge based segmentation. In this analysis, a new quantization technique for HSV (Hue, Saturation, Value) color space is implemented to develop a color histogram for K-Means clustering, which operates across disparate dimensions in HSV color space.

B) Inter and Intra band clustering:

Supposedly, Clustering targets to identify and create structure in data sets by determining and evaluating similarities among specific data patterns. The basic idea in most clustering algorithms is to identify a set of points and then update pattern membership to clusters iteratively, so as to achieve a better partition. Vector quantizations provides a means of decomposition of the signal in an approach which takes the improvement of intra and inter band correlation as a more lithe partition for higher dimension vector spaces (G. Boopathy and S. Arockiasamy, 2010). The vector quantization is a classical quantization approach from signal processing and image compression, which concedes the modeling of probability density functions of the distribution of prototype vectors. The accurate classification of remote sensing is an imperative task for many practical applications, such as precision agriculture, monitoring, management of the environment, security and defense issues (Y. Tarabalka, *et al.*, 2009). Besides that, a new spectral, spatial classification pattern for hyperspectral images is proposed. The method incorporates the results of a pixel wise support vector machine classification and the segmentation map attained by partitioned clustering using majority voting.

Reputably, the ISODATA algorithm and Gaussian mixture resolving schemes are used for image clustering. The cluster based segmentation methods desires in finding distinct structures in the spectral feature space. Thus, clustering is a comprehensive partitioning of a set of pixels from the input image into homogeneous groups of pixels. In this paper, the cluster based segmentation of hyper spectral images will be examined. Clustering is a search for hidden patterns that may exist in datasets. It is a technique of grouping data objects into disjointed clusters so that the data in each cluster are similar, yet disparate to the others. Clustering methods are applied in many application areas such as pattern recognition, data analyses, information retrieval and image processing.

C) Multispectral image segmentation:

Intuitively, Geographic Object Based Image Analysis (GEOBIA) (G. Hay and G. Castilla, 2008) is a sub-discipline of Geographic Information Science (GI Science) devoted to developing automated methods to partition remote sensing imagery into meaningful image objects. This research (M. Kim, *et al.*, 2009) investigated the use of a Geographic Object Based Image Analysis (GEOBIA) approach with the incorporation of object specific Gray Level Co-occurrence Matrix (GLCM). The GEOBIA approach has the potential to overcome inherent problems of high spectral variability within the same land-cover classes in VHR (Very High Resolution) imagery. Object Based Image Analysis (OBIA) is gaining rapid popularity in remote sensing science as a means of bridging Very High Spatial Resolution (VHSR) imagery (L. Drăguţ, *et al.*, 2010). Classification algorithms based on single-pixel analysis often do not give the aimed result when enforced to high spatial resolution remote sensing data (M. Bouziani, *et al.*,2010). The pixel oriented approach is not appropriate to use geometric and contextual attributes. An object oriented approach is needed. Thus, a multi spectral image segmentation method should be used to generate objects.

Presumptively, the Multi-spectral Local Differences Texem (MLDT) is an affordable procedure to be used in multi spectral images that may contain extensive number of bands (F. Pla, *et al.*,2009). Multi and hyper spectral sensors acquire information in several spectral bands, which develop hyper spectral data in high dimensional spaces. Multi spectral image data are used in order to evaluate and interpret the types of vegetation, land, water and other man-made objects. Standard multispectral image interpretation approaches scarcely exploit the spectral, spatial relationships in the image. The multi spectral image data is inherently treated as a set of independent spectral measurements at each pixel location without taking into account their spatial relations.

D) Hyper spectral image processing:

Doubtlessly, Hyper spectral imaging is a new remote sensing scheme that develops hundreds of images, comparable to disparate wavelength channels, for the same area on the surface of the earth (J. Plaza, *et al.*, 2009). Supervised classification of hyper spectral image dataset is a demanding obstacle due to the limited availability of training samples. The myriad spectral bands acquired by hyper spectral sensors enhances the competence to discriminate physical materials and objects presenting new challenges to image analysis and classification (Y. Tarabalka, *et al.*, 2010). Hyper spectral imaging sensors measure the energy of the received light in tens or hundreds of narrow spectral bands in each position in the image. Markov Random Fields (MRFs) are probabilistic models that are commonly used to integrate spatial context into image classification problems.

Allegedly, Imaging spectroscopy, also known as hyper spectral imaging (A. Plaza, *et al.*, 2009), is concerned with the measurement, analysis and interpretation of spectral acquired from a given scene (or specific object) at a momentary, moderate or protract distance by satellite sensor. The special characteristics of hyperspectral datasets pose various processing obstacles, which must be automatically tackled under specific mathematical formalisms, such as classification and segmentation or spectral mixture analysis. The signification of analyzing spatial and spectral patterns simultaneously has been identified as a desired goal by many scientists devoted to multidimensional data analysis. The covariance matrix is a key component in an immense array of statistical signal processing tasks applied to remote sensing imagery from multispectral and hyper spectral sensors (J. Theiler, *et al.*, 2011). It paves to evaluate performance on covariance matrices that are observed in real hyper spectral imagery. Hyper spectral sensors simultaneously capture hundreds of narrow and contiguous spectral images from a extensive range of the electromagnetic spectrum (B. Guo, *et al.*, 2008). Hyper spectral sensors capture signals in a wide spectrum and it can be expected that different parts of the spectrum will have differing representative capabilities for distinguishing the objects of interest.

Tacitly, with the recent developments in remote sensing instruments, hyper spectral images are now prodigiously used in disparate application domains (J. Li, *et al.*, 2011). The special characteristics of hyperspectral data sets shepherd inappropriate processing problems. A well-known strenuously in supervised hyper spectral image classification is the slandered availability of training data, which are burdensome to obtain in practice as a matter of cost and time. A pristine method for segmentation and classification of hyper spectral images is proposed in this analysis (Y. Tarabalka, *et al.*, 2010). The method is based on the construction of a Minimum Spanning Forest (MSF) from region markers. The construction of MSF belongs to graph based approaches for image segmentation. Furthermore, the segmentation and classification of the image were performed by constructing MSF based on the selected markers. Watershed transformation is one of the most powerful tools for image segmentation.

Seemingly, the segmentation by the watershed of hyper spectral images has shown to improve the results of classification in hyper spectral images. An imperative aspect of spectral image analysis is description of materials present in the object or scene being imaged. Band selection is a frequent approach for dimensionality reduction (H. Yang, *et al.*, 2011). When the desired object information is unknown, an unsupervised band selection technique is employed to select the most distinctive and informative bands. Compared to supervised band selection techniques, unsupervised methods need no priori information about objects and classes.

E) K-Means Clustering:

Theoretically, K-Means is a typical algorithm. Now that it is elementary and expeditious, it is attractive in practice. To begin with, it segregates the input dataset into k-clusters. Each cluster is described by an adaptively changing centroid, starting from some initial values named seed points. K-Means enumerates the squared distances between the inputs and centroids, and assigns inputs to the nearest centroid. K. R. Zalik (2008) recommends K-Means algorithm that implements correct clustering without pre-assigning the exact number of clusters. As a traditional clustering algorithm, K-Means is suitable for its simplicity for implementation and it is generally applied for grouping pixels in images or video sequences. The major deficiency of the K-Means algorithm is that the number of clusters must be pre-determined and fixed. Selecting the appropriate number of clusters is critical. It requires a priori knowledge about the data or, in the worst case, guessing the number of clusters.

Besides, the performances of the K-Means algorithm depend on initial cluster centers. Furthermore, the final partition depends on the initial configuration. Solving the selection of a correct cluster number has been tried in two ways. The first one invokes some heuristic approaches (A. K. Jain, 2010). The clustering algorithm is run many times with the number of clusters gradually increasing from a certain initial value to some threshold value that is difficult to set. The second is to formulate cluster number selection by choosing a component number in a finite mixture model. Despite being widely used in data analysis, pattern recognition and image processing, K-means has three major constraints:

- The number of clusters must be previously known and fixed.
- The results of K-Means algorithm depend on initial cluster centers.
- The algorithm contains the dead-unit problem.

F) *Fuzzy C-Means (FCM) clustering:*

Apperently, F. Golichenari and M. Gholami, (2009) demonstrate clustering is the process of assigning data objects into a set of disjoint groups called clusters so that objects in each cluster are more similar to each other than objects from various clusters. Clustering technique is applied in many application areas such as pattern recognition, data mining, machine learning, etc. A. Sopharak, *et al.*, (2009) suggests a variation of Fuzzy C-Means (FCM) algorithm that contributes image clustering. The modified algorithm is called Fuzzy Local Information C-Means can vanquish the drawbacks of the known Fuzzy C-Means algorithms. Besides, it improves the clustering performance. The major FLICM is the use of a fuzzy local resemblance measure, focusing to guarantee noise insensitiveness and image detail preservation. Furthermore, a remote sensing image segmentation procedure that utilizes a single point iterative weighted FCM clustering is proposed based upon the prior information. Moreover, this method can solve the FCM algorithm's problem that the clustering quality is substantially affected by the data, distributing and the stochastic initializing the centrals of clustering. Clustering analysis based methods can provide a nonparametric, unsupervised approach to the analysis of each kind of images. Numerous modified classifiers based on FCM algorithms have been applied for image segmentation. In (V.Saravana Kumar, E.R. Naganathan *et al*, 2014) segmentations were carried out using Enhanced Estimation of Centroid in Hyper spectral scene with K-Means and Fuzzy C- Means.

G) *Hard C-Means (HCM) Clustering:*

Surely, one of the most penny plain clustering techniques is HCM clustering (J. Fan, *et al.*, 2009). In this method, from a set of patterns, *c* numbers of patterns are randomly chosen as initial cluster centers of the clusters are updated after assignment of all patterns. FCM algorithm has proved its efficacy for image segmentation. On the flip side, still it lacks in getting robustness to noise and outliers, specifically in the absence of prior knowledge of the noise. To overcome this dilemma, a speculated Novel Multiple Kernel Fuzzy C-Means (NMKFCM) technique with spatial information is imported as a framework for image segmentation obstacle (A. Ghosh, *et al.*, 2011). This algorithm exploits the spatial neighborhood membership values in the standard kernels are used in the Kernel FCM (KFCM) algorithm and reforms the membership weighting of each cluster.

Doubtlessly, K-Means is one of the hard clustering methods. The conventional hard clustering methods classify each point of the data set to one cluster. Among the fuzzy clustering methods, FCM algorithm is one of the most prominent techniques used in image segmentation because it has robust characteristics for ambiguity and can retain much more information than hard segmentation methods. FCM algorithm is a generalization of the Hard C-Means algorithm yields extremely good results in an image region clustering and object classification. As in Hard K-Means algorithm, FCM is based on the minimization of a criterion function.

Table 1: Techniques for hyperspectral image segmentation and multiband reduction.

Authors	Year	Technique	performance
Chen, *et al*.	2008	Quantization technique for HSV (Hue, Saturation, Value) color space	HSV color space is implemented to generate a color
Tarabalka, *et al*.,	2009	ISODATA algorithm and Gaussian mixture resolving technique	This method is well for classification of images with large spatial structures
Bouziani, *et al*.,	2010	High resolution satellite imagery and rule based classification	Rule based classification using geometric, spectral, contextual information and textural.
Plaza, *et al*.,	2009	Spectral mixture analysis and Kernel methods	This analysis explores the development of parallel processing
Li, *et al*.,	2011	Supervised Bayesian segmentation approach	Bayesian segmentation approach addressing ill-posed hyperspectral classification and segmentation problems
Yang, *et al*.,	2011	Similarity based unsupervised band selection	This algorithm is applied in the spatial domain for band selection
Fan, *et al*.,	2009	Weighted Fuzzy C-Means clustering algorithm	This method can solve the FCM's problem
Ghosh, *et al*.,	2011	Context sensitive technique	Two fuzzy clustering algorithms namely, FCM and Gustafson-Kessel Clustering (GKC) algorithms have been used
Žalik	2008	K-Means clustering	It performs correct clustering without pre-assigning the exact number for clusters
Paoli, *et al*.,	2009	Multi Objective Particle Swarm Optimization (MOPSO)	It detects the best discriminative bands without requiring the *a priori* setting of their number by the user
Yang, *et al*.,	2009	K-Harmonic Means (KHM) clustering and hybrid data clustering algorithm based on PSO	It solves the problem of initialization using a built-in boosting function

H) *Particle Swarm Optimization (PSO):*

Ostensibly, Particle Swarm Optimization (PSO) algorithms represent a new approach for optimization. A clustering based PSO finds the centroids of a user specified number of clusters, where each cluster groups together similar patterns. PSO is facile to implement and has been successfully applied to elucidate a sizeable range of optimization problems such as linear and discrete optimization problems. N. Venu and B. Anuradha, (2013), confer a new methodology for clustering hyper spectral images. It targets at synchronously solving the following three disparate issues:

- Estimation of the class statistical parameters.
- Detection of the best discriminative bands without requiring the *a priori* setting of their number by the user.
- Estimation of the number of data classes describing the examined image.

It is formulated within a Multi Objective Particle Swarm Optimization (MOPSO) framework. The objective of this research is to propound a novel methodology for hyper spectral images capable of simultaneously solving the above problems, i.e. Clustering, feature detection and class number estimation. The objective is to classify the image in an unsupervised way. Given its hyper spectral nature, it is preferable to perform beforehand a feature detection operation. PSO (K. R. Zalik, 2008) is a population based search method, which exploits the concept of social sharing of information. This means that each individual (called particle) of a given population (called swarm) can profit from the previous experiences of all other individuals from the same population. PSO is a prominent and robust method for optimization problems A. K. Jain, (2010). But the main obstacle in resolving PSO to real world applications is that PSO typically need an extensive number of fitness appraisals before a gratifying result can be attained. In this analysis, the improved algorithm, Fuzzy C-Mean based in Picard iteration and PSO (PPSO – FCM) is proffered.

RESULTS AND DISCUSSION

Reasonably, the results of the survey are shown in table 1. Variegated approaches for hyper spectral image segmentation and disparate clustering approaches for multiband reduction are depicted. A clustering and fusion method improves the classification performance of hyper spectral imagery. The PSOKHM algorithm searches robustly the data cluster centers using the sum over all data point to all the centers as a metric. To diminish computation complexity, band selection can be conducted on automatically selected pixels from the N-FINDR algorithm. A remote sensing image segmentation procedure that utilizes a single point iterative weighted FCM clustering algorithm based upon the prior information. Plethoras of spectral channels in a hyper spectral image are spiral up the potential of discriminative physical materials and structures in a scene.

2. Conclusion:

To be crisp, the paper comprises the survey results in hyper spectral image segmentation and multiband reduction. In addition, the survey depicts various methods and techniques such as K-Means clustering, Fuzzy C-Means clustering, Particle Swarm Optimization, K-Harmonic Means clustering, Particle Swarm Clustering, Multi Objective Particle Swarm Optimization and unsupervised Bayesian segmentation approach. As a future work, the hyper spectral image segmentation and multiband reduction will have performed with meager time and computational complexity.

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