International Journal of Current Engineering and Technology ISSN 2277 – 4106

Available at http://inpressco.com/category/ijcet

Research Article

Implementation of Segmentation Techniques for Multispectral Satellite Images

Snehal B Ashtekar[a*], Vijay. S. Rajpurohit[a] and Anil B. Gavade[b]

[a]Department of Computer Science and Engineering
[b]Department of Electronics and Communication Engineering, KLS Gogte Institute of Technology, Belgaum-59008, INDIA.

Abstract

This paper reviews the wide range of Image segmentation techniques that are used to segment satellite images. The process of partitioning a digital image into multiple segments i.e. set of pixels is called segmentation. The pixels in a region can be similar due to some homogeneity criteria such as color, intensity or texture. A satellite image is a multispectral image that captures image data at specific frequencies across the electromagnetic spectrum. Spectral imaging can allow extraction of additional information the human eye fails to capture with its receptors for red, green and blue. Multispectral images are the main type of images acquired by remote sensing (RS).Since we use the LISS III the multispectral images lie in the band ranging from 0.62 to 1.78 micro meters. From the pool of segmentation methods available we consider the Kmeans, Fuzzy C means, marker controlled watershed, Wavelet, Level set, Quick Shift, Ant Colony Optimization for Thresholding techniques for segmenting satellite images. Several parameters such as mean, standard deviation, variance etc are considered in order to be used for comparison of the techniques.

Keywords: *Image segmentation techniques ,Multispectral images, Satellite images Kmeans, Fuzzy C means, Marker controlled watershed, Wavelet, Level set, Quick Shift, Ant Colony Optimization for Thresholding .*

1. Introduction

In recent years the urbanization has led to decrease in the use of land for agriculture and cultivation. The use of Remote sensed Satellite images to analyze the land cover is a process that is been carried out for a long time now. In order to obtain useful information from the satellite images which covers a wide area measured in several kilometers and objects that range from buildings to water-bodies to noise, clouds etc.

We first need to segment the images to obtain the area of interest. The process of segmentation is the first step for any future analysis of an image. There are a large number of segmentation techniques that are available for this process. There is no particular standard technique or method that has been identified as the most suitable or best for a particular type or size of image.

The overall goal of this review is to explore and understand the pool of segmentation techniques and select a set of eight techniques that most aptly suit the segmentation of Multispectral images. This is done with the understanding of Remote sensing and the issues involved with the satellite images. Another objective is to obtain one standard segmentation technique that can be applied for the segmentation of LISS III images.

Segmentation refers to the process in which a digital image is partioned into multiple segments(sets of pixels,).Image segmentation can be used to locate boundaries and objects (lines, curves, etc.) in images. [Dihua Guo, et al,2010]. To state precisely, image segmentation is the process of assigning a label to every pixel in an image .The pixels with the same label share certain characteristics which are either visual or specific. From the segmented image, we get to know that which pixel belongs to which object. The different types of segmentations are:

Pixel-Based Segmentation: it's the simplest approach and is done based on pixel graylevel values .Its also called as point based segmentation.

Edge-Based Segmentation: An *edgebased segmentation* approach can be used to avoid a bias in the size of the segmented object without using a complex thresholding scheme. Edge-based segmentation is based on the fact of the first-order derivative that is position of an edge is given by an extreme

Region-based: Region based methods are robust because they cover more pixels than edges and thus you have more information available in order to characterize your region.

Model-Based Segmentation :The human vision system has been able to recognize objects even if they are not completely clear or represented. It is obvious that the information that can be gathered from local neighborhood operators is not sufficient to perform this task. Instead we need specific knowledge about the geometrical shape of the objects required, which can then be compared with the

*Corresponding author: **Snehal B Ashtekar**

local information. This train of thought leads to *model-based segmentation (*Dihua Guo, et al, 2010*).*

Multispectral imaging refers to the use of several different spectral bands when acquiring images. Remote sensing and more precisely imaging ultraviolet (UV) and infrared (IR) bands with normal RGB-based visible light are the most common application for multispectral images. A *multi-spectral* image is a collection of several monochrome images of the same scene, each one taken with a different sensor. Each image is referred to as a *band*. In image processing, multi-spectral images are most commonly used for Remote Sensing applications. While displaying the different bands of a multispectral data set,images obtained in different bands are displayed in image planes (other than their own) the color composite is regarded as False Color Composite (FCC).High spectral resolution is important when producing color components. A multispectral image is one that captures image data at specific frequencies across the electromagnetic spectrum. Since we use the LISS 111 the multispectral images lie in the band ranging from 0.62 to 1.78 micro meters.

Spectral imaging can allow extraction of additional information the human eye fails to capture with its receptors for red, green and blue. Remote Sensing images are frequently influenced by several changes, such as camera viewpoints, distance and illuminance, so different targets automatic recognition methods in remote sensing images by using edges or gradient have attracted many researchers in recent years.

There is a pool of segmentations algorithms that are available for segmenting Satellite(remote sensed) images. The motive of this survey is to find the most suitable Segmentation technique and perform a comparison based on a set of parameters. This will help us find the most suitable technique that can be used for segmentation of satellite images.

2 .The Multispectral Satellite Image(IRS)

A *multi-spectral* image is a collection of several monochrome images taken from the same scene, each one of it taken with a different sensor. Each image is called as a *band*. The distinction between hyper spectral and multispectral is usually defined as the number of spectral bands.

- Multispectral data contains from tens to hundreds of bands. Hyper spectral data contains hundreds to thousands of bands.
- The RESOURECSAT-1 satellite(w.r.t IRS only) was launched in to the polar sun synchronous orbit (altitude of 817 km) by PSLV-C5 launch vehicle on October 17, 200
- RESOURCESAT-1 is also called IRS-P
- RESOURCESAT-1 carries three sensors
- High Resolution Linear Imaging Self-Scanne(LISS-IV)
- Medium Resolution Linear Imaging Self-Scanner (LISS-III)
- Advanced Wide Field Sensor (AWiFS).The Multispectral images under study belong to the images captured by LISS II
- The LISS-III is a medium resolution sensor.
- Quantization: bits (SWIR band 10 bits – VNIR selected 7 bits transmitted)
- Ground swath is 141 km with 24 day repeat cycle and Operates in four spectral bands
- Each band consists of a separate lens assembly & linear array CCD

3.Related Work

The problems of digital image segmentation represent great challenges for computer vision. The wide range of the problems of computer vision may make good use of image segmentation. The study (Ashraf A. Aly1 ,et al 2011)evaluates the different methods for segmentation techniques. and reviews the segmentation. which is useful for determining the appropriate use of the image segmentation methods and for improving their accuracy and performance and also for the main objective, which designing new algorithms.

The authors gives a study of the various algorithms that are available for color images, text and gray scale images(Dihua Guo et al 2010) .Due to the importance of image segmentation a number of algorithms have been proposed but based on the image that is inputted the algorithm should be chosen to get the best results.

Self-Organizing Maps (SOMs) and Fuzzy C-Means (FCM) segmentation methods are discussed in (] Mohamad M. Awad1 et al, 2009).These two important known methods are reviewed, and summarized. A new cooperative approach which combines the advantage of two or more methods to segment different types of satellite images successfully and very fast. Moreover, the approach is automatic with no supervision and with no or minimum . The approach was compared to each method separately and to ISODATA. The comparison showed that the approach provided the highest accuracy (93%).

A proposed an approach for segmenting the multispectral QuickBird image based on first fundamental form(Pengfeng XIAO et al 2009). The value of multispectral image at a given point can be regarded as N-dimensional vector, and the difference of image values can be defined from the theory of first fundamental form, which allows to access gradient information from all bands simultaneously. Thus it is used to fuse the gradient feature of all bands. Then, the image segmentation is implemented based on marker-controlled watershed transform. The experimental results show that the proposed approach gives a better solution of integrating multispectral information for the segmentation of remotely sensed imagery.

The coarse-to-fine level set method to extract object contours for optical satellite images. (Qizhi Xu, et al 2009).The experiments on a large satellite-image database demonstrated that the proposed method achieves encouraging performance on the running time and

improves the accuracy of the extracted contours, particularly the contours obtained from noisy images.

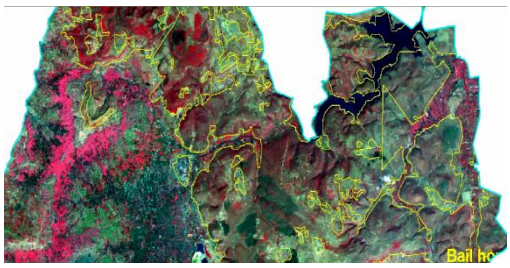
It has been demonstrated that increasing the number of spectral samples in the visible range with a multispectral camera can improve K-means clustering performance(Roarke Horstmeyer,et al 2010).It furthermore demonstrates how extending spectral samples outside of the visible range easily separates otherwise invisible clusters. A novel algorithm is developed to combine the perceptual-based color segmentation used on RGB images with the statistical clustering methods of hyperspectral data. Finally, initial work in determining an optimal set of color filters for segmentation is presented with the goal of designing a learning algorithm for this task in the future.

A efficient implementation of Lloyd's k-means clustering algorithm, which we call the filtering algorithm. This algorithm is easy to implement(Tapas Kanungo,et al 2002) .They establish the practical efficiency of the filtering algorithm in two ways. First, present a data-sensitive analysis of the algorithm's running time, which shows that the algorithm runs faster as the separation between clusters increases. Second, present a number of empirical studies both on synthetically generated data and on real data sets from applications in color quantization, data compression, and image segmentation. The proposed method demonstrates excellent performance in high-resolution remotely sensed imagery even where complicated urban district area.

It has been proposed that a variation level-set method for unsupervised change-detection in remote sensing images in the paper(XIAO Pengfeng,2009). The discrimination between changed and unchanged classes in the difference image is achieved by defining an energy functional known as the piecewise constant approximation Mumford-Shah segmentation model. The minimization of this energy functional is realized according to an attractive level-set method seeking to find an optimal contour which splits the image into two mutually exclusive regions associated with changed and unchanged classes, respectively. In order to increase the robustness against the initialization issue, we adopt a multiresolution level-set approach by analyzing the difference image at different resolution levels.

A novel methodology base on multi-feature object-oriented MRF(MFOMRF) is proposed in order to obtain precise segmentation of high resolution satellite image(Yakoub Bazi et al 2009).Conventional pixel-by-pixel MRF model methods only consider spatial correlation and texture of each pixel fixed square neighborhood ,which are not satisfactory as the high resolution satellite contains complex spatial and texture information. the segmentation method of high resolution remote sensing image based on pixel-by-pixel MRF model usually suffer from salt and pepper noise. Based on the analysis of problems existing in pixelby-pixel MRF model methods of high-resolution remote sensed images, an multi-feature object-oriented MRF-based segmentation algorithm is proposed.

4.LISS III image and Bands



Courtsey(KSRSAC:IRS RESORCSAT, LISS III image)

The above image is a LISS III jpeg image, for the Belgaum region .It has the three color Guns: red ,green and blue..It has the regions in terms of:

- Vegetation: Red and yellow
- Uncultivated: brown

5.The Segmentation techniques and Parameters

The techniques that are considered along with the parameters are:

Techniques:

- Wavelet Transform
- K-Means using Cosine Distance
- Marker controlled Watershed
- Fuzzy C means
- Level set
- Quick Shift
- Ant Colony Optimization: Thresholding
- C*I*E lab

Parameters:

- Mean
- Median
- Standard Deviation
- SNR(signal to noise Ratio)
- CPU time

Technique 1:

1.Wavelet Transform:

Wavelets can be used to extract information from many different kinds of data, including –audio signals and images. A wavelet is a wave-like oscillation with an amplitude that begins at zero, increases, and then decreases back to zero. Wavelets allow complex information such as music, speech, images and patterns to be decomposed into elementary forms at different positions and scales and subsequently reconstructed with high precision.
Daubechies

Ingrid Daubechies, one of the brightest stars in the world of wavelet research, invented what are called compactly supported orthonormal wavelets -- thus making discrete wavelet analysis practicable. The names of the Daubechies family wavelets are written dbN, where N is the order, and db the surname of the wavelet. The db1 wavelet, as mentioned above, is the same as Haar wavelet.

- The wavelets method is the one which least distorts the spectral characteristics of the data. The distortions are minima
- The wavelet based method is the most efficient in preserving the spectral information contained in the original multispectral images.
- Wavelets have the great advantage of being able to separate the fine details in a signal. Very small wavelets can be used to isolate very fine details in a signal, while very large wavelets can identify coarse details. A wavelet transform can be used to decompose a signal into component wavelets.

Technique 2:

2. Kmeans:

K-means is one of the most widely used unsupervised learning algorithms. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters fixed priori. The main idea is to define k centroids, one for each cluster. These centroids should be placed in cunning way because of different location cause different result. So the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest centroid .When no point is pending, the first step is completed and an early group is done. At this point we need to re- calculate k new centroids .

The next step is to take each point belonging to a given data set and associate it to the nearest centroid .a new binding has to be done between the same data set pints and the nearest new centroid .A loop has been generated as a result of this loop we may notice that the k centroids change their location step by step until no more changes are done .In other word centroids do not have anymore .

The Cosine distance instead of Sqeuclidean distance can be used to find the centroid of cluster as it reduces computation time of the algorithm. The cosine similarity as quantified the cosine angle between vectors. Cosine similarity is one of the most popular similarity measure applied The cosine distance is calculated using:

$$d(x,y) = 1 - \frac{cos^{-1}}{\pi} \ (similiarity)$$

Using the cosine distance based image segmentation, it is possible to reduce computational time and cost

Technique 3:

3.Marker controlled watershed

Watershed model is a mathematical morphological approach and derives its analogy from a real life flood situation .It transforms image into a gradient image(Dey A,2010)Then, image is seen as a topographical surface where grey values are deemed as elevation of the surface at that location. Then, flooding process starts in which water effuses out of the minimum grey value.

When flooding across two minimum converges then a dam is built to identify the boundary across them. This method is essentially an edge based technique .The original watershed algorithm was susceptible to over segmentation so a modified marker-controlled based watershed algorithm was proposed by Beucher (1992).

The a marker- controlled method is used to conquer the over-segmentation problem of watershed transform(Rajeshwar Dass et al 2012). Use different scale of the marker image can produce segmentation results in different scale. Generally, small minsize value produce smallscale segmentation results, whereas large minsize value produce large-scale segmentation results(Rajeshwar Dass,et al 2012)

Technique 4:

4.*Fuzzy C means:*

Clustering is the process of grouping a data set in a way that the similarity between data within a cluster is maximized while the similarity between data of different clusters is minimized .There are two main approaches to clustering. One method is crisp clustering (or hard clustering), and the other one is fuzzy clustering. A characteristic of the crisp clustering method is that the boundary between clusters is fully defined. However, in many real life cases, boundaries between natural classes maybe overlapping. So, certain input patterns do not completely belong to a single class, but partially belong to the other classes too. In such cases, the fuzzy clustering method provides a better and more useful method to classify these patterns.

There are many fuzzy clustering methods being introduced . Fuzzy C-means clustering algorithm is one of most important and popular fuzzy clustering algorithms

In fuzzy clustering (also referred to as soft clustering), data elements can belong to more than one cluster, and associated with each element is a set of membership levels. These indicate the strength of the association between that data element and a particular cluster. Fuzzy clustering is a process of assigning these membership levels, and then using them to assign data elements to one or more clusters.

Technique 5

5.Level Set:

The Level Set technique is a shape extraction procedure that works by expanding a starting point or curve and aggregating new points, according to geometric, mathematical, and statistic criteria. This technique has proved to be effective for the extraction of significant

objects from various types of images. The role of a level set method for image processing often relates to PDE techniques involving one or more of the following features: 0) regarding an image as a function sampled on a given grid with the grid values corresponding to the pixel intensity in suitable color space, 1) regularization of the solutions, 2) representing boundaries, and 3)the numeric's developed for the level set methods. Particularly in light of 2), it is not hard to seek an application of the level set method for segmentation

Technique 6:

6:Quick Shift

Quick Shift is a mode seeking algorithm which instead of iteratively shifting each point towards a local mean forms a tree of links to the nearest neighbor which increases the density. Quick shift arranges all of the data points into a tree where parents in the tree are the nearest neighbors in the feature space which increase the estimate of the density. By imposing a limit on the distance between nearest neighbors (maxdist), we decrease the amount of computation required to search for the nearest neighbors. However, we also break our tree into a forest, because local modes of the density will now have no neighbor which is close enough in the feature space to form a link.

Technique 7:

7:Thresholding using ANT Colony Optimization

The popular technique in image segmentation is the thresholding segmentation because of its simplicity and efficiency. If the target is clearly distinguishable from the background, the histogram of the image will be bimodal and then it can easier get to the threshold by simply choosing the valley bottom as the threshold point. However, in most of real images, there are not clearly distinguishable marks between the target and the background. Ant Colony Optimization Algorithm (ACO) (Dey A 2010)(Dihua Guo) which is a kind of bionic evolution, one was invented by an Italian Scholar M.Dorigo. It was inspired by the observation of real ant colony and used to find an optimal path to food source in the food searching process.

In the real world, ants are social insects and live in colonies. Their behavior is directed more to the survival of the colony as a whole than to that of a single individual component of the colony. An important and interesting behavior of ant colonies is their foraging behavior, and, in particular, how ants have the capability to find the shortest paths between food sources and their nest.

The Ant colony optimization (ACO) algorithm is relatively a new meta-heuristic algorithm and a successful paradigm of all the algorithms which take advantage of the insect's behavior. It has been applied to solve many optimization problems with good discretion, parallel, robustness and positive feedback

Image thresholding is a challenging problem. A new improved image thresholding method based on the ant colony optimization algorithm. Adopting this method to process image segmentation, not only efficiently segments the target and the background, but also provides the most important success that, it segments thin parts more nicely, and it obtains satisfactory effect.

5.Parameters for comparison:

The parameters used for comparison of the Segmentation techniques are:

Mean :

The standard definition of mean states Average or mean value of array. The Image is in form of a matrix

Variance:

The Variance computes the unbiased variance of each row or column of the input, along vectors of a specified dimension of the input, or of the entire input. The Variance block can also track the variance of a sequence of inputs over a period of time. The block computes the variance of each row or column of the input, along vectors of a specified dimension of the input, or of the entire input at each individual sample time, and outputs the array *y*. Each element in *y* is the variance of the corresponding column, row, vector, or entire input.

Standard deviation

Standard deviation (represented by the symbol sigma, σ) shows how much variation or dispersion exists from the average (mean), or expected value. A low standard deviation indicates that the data points tend to be very close to the mean; high standard deviation indicates that the data points are spread out over a large range of values. A useful property of standard deviation is that, unlike variance, it is expressed in the same units as the data. Note, however, that for measurements with percentage as unit, the standard deviation will have percentage points as unit.

SNR(Signal to noise ratio):

Signal-to-noise ratio (often abbreviated SNR or S/N) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power. A ratio higher than 1:1 indicates more signal than noise

Conclusion

In this paper, a study is made on few of the segmentation techniques out of the widely available pool of techniques.it has been observed that with a little modification to the existing segmentation algorithm a large improvement can

be achieved in its performance. For instance use of cosine distance in Kmeans to improve CPU time or use of Markers in Watershed to reduce oversegmentation that occurs with watershed algorithm .The study concludes with the fact that the existing segmentation methods can be applied for segmentation of Satellite Images, and a comparison can be performed with suitable parameters on the selected techniques to help us select the suitable segmentation technique for the segmentation of the satellite image

References

Ashraf A. Aly, Safaai Bin Deris, Nazar Zaki (2011), Research Review For Digital Image Segmentation Techniques*International Journal of Computer Science & Information Technology* , Vol 3, No 5, Oct 2011.

B. Kartikeyan (1998), A segmentation approach to classification of remote sensing imagery Space Applications *Int. j. remote sensing*, vol. 19, no. 9, 1695 ± 1709

Dey a , Y. Zhang a, M. Zhong : Wagner W., Székely, B. (eds) (2010)Review On Image Segmentation Techniques With Remote Sensing Perspective ISPRS TC VII Symposium – 100 Years ISPRS, IAPRSVol. XXXVII.Vienna, Austria.

Dihua Guo, Vijayalakshmi Atluri and Nabil Adam Texture-Based Remote-Sensing Image Segmentation

Krishna Kant Singh , Akansha Singh (2010), A Study Of Image Segmentation Algorithms ForDifferent Types Of Images *IJCSI International Journal of Computer Science* Issues, Vol. 7, Issue 5.

Mohamad M. Awad1, Ahmad Nasri (2009), Satellite Image Segmentation Using Self-Organizing Maps and Fuzzy C-Means 978-1-4244-5950-6/09/$26.00 IEEE

Petros S. Karvelis, Dimitrios I. Fotiadis, Ioannis Georgiou and Marika Syrrou (2006), A Watershed Based Segmentation Method for Multispectral Images Classification Proceedings of the 28th IEEE EMBS Annual International Conference New York City, USA

Pengfeng XIAO, Xuezhi FENG, Hui LI (2009), Multispectral Remotely Sensed Imagery Segmentation Based on First Fundamental Form 978-1-4244-3461-9/09/$25.00 ©2009 IEEE

Qizhi Xu, Bo Li, Zhaofeng He, and Chao Ma (2011), Multiscale Contour Extraction Using a Level Set Method in Optical Satellite Images IEEE geoscience and remote sensing letters, vol. 8, no. 5.

Roarke Horstmeyer (2010), Multispectral Image Segmentation MIT Media Lab 6.869 Final Project, *Spring*

Rajeshwar Dass, Priyanka, Swapna Devi (2012),Image Segmentation Techniques, IJECT Vol. 3, Issue 1.

Tapas Kanungo (200, 2)An Efficient k-Means Clustering Algorithm:Analysis and Implementation *IEEE transactions on pattern analysis and machine intelligence*, vol. 24, no. 7.

Tanvi Madaan, Himanshu Sharma (2012), Object detection in remote sensed images *International Journal of Scientific and Research Publications*, Volume 2, Issue 6, 1 ISSN 2250-3153.

Torsten Seemann Digital Image Processing usingLocal Segmentation B. Sc (Hons) School of Computer Science and Software Engineering Faculty of Information Technology Monash University Australia.

W. Frei and C.-C. Chen (1977), Fast boundary detection: A generalization and a new algorithm . *lEEE Trans. Comput.*, vol. C-26, no. 10, pp. 988-998.

W. E. Grimson and E. C. Hildreth (1985), Comments on Digital step edges from zero crossings of second directional derivatives''. *IEEE Trans. Pattern Anal. Machine Intell.*, vol. PAMI-7, no. 1, pp. 121-129, 1985.

XIAO Pengfeng, Xuezhi FENG, Hui LI (2009), Multispectral Remotely Sensed Imagery Segmentation Based on First Fundamental Form 2009 Urban Remote Sensing Joint Event 978-1-4244-3461-9/09/$25.00 ©2009 IEEE

Yang Kun (2011), A novel segmentation method of high resolution remote sensing image based on multi-feature Objectoriented Markov Random Fields Model 978-1-4244-9171-1/11/$26.00 ©2011 IEEE

Yakoub Bazi, and Farid Melgani (2009) A Variational Level-Set Method for Unsupervised Change Detection in Remote Sensing Images 978-1-4244-3395-7/09/$25.00 ©2009 IEEE, IGARSS 2009