Combined approach for Colour Image Segmentation on Satellite Images

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Abstract:

Image segmentation is the basis of Image analysis and understanding. It is a crucial part of an oldest and harvest problem of Image processing. Satellite Image segmentation is a complex and challenging task due to the intrinsic nature of the image. Here we take some sample Satellite Image in the form of RGB as input images. A large variety of different segmentation approaches for image have been developed. The single arithmetic of colour image segmentation has some deficiencies and defects, so we can combine different algorithm according to the actual situation for segmentation. Here, we propose a novel approach for colour image segmentation called JSEG applied on Satellite Image in the form of RGB. The JSEG algorithm segments the satellite image in the form of RGB, properly without manual parameter adjustment for each image and simplifies texture and colour. Segmentation with this algorithm passes through two major stages, namely colour space quantization and hit rate regions with similar colour regions merging.

Keywords: Satellite Image, Segmentation, Clusters, and Region growing.

Introduction:

Image segmentation is a key step from the image processing to image analysis, it occupy an important place. It is the basis of target expression and has important effect on the feature measurement. The target expression based on segmentation, the feature extraction and parameter measurement that converts the original image to more abstract and more compact form. In the actual production life, the application of image segmentation is also very wide and almost appeared in all related areas of image processing as well as involved various types of images. For example, satellite image processing in the application of remote sensing, the brain MR image analysis in the application of medicine, the plates of illegal vehicle region segmentation in the traffic image analysis, the image region of interest extraction in the object-oriented image compression and content-based image retrieval [3]. In these applications, image segmentation is usually used for image analysis, identification and compress code, etc.

Human eyes can distinguish thousands of colours but can only distinguish 20 kinds of gray scale, so we can easily and accurately find the target from the colour images. However, it difficult to find out from the gray-scale image. The reason is that colour can provide more information than gray scale. The colour for the pattern recognition and machine vision is very useful and necessary. At present, specifically applied to the colour image segmentation approach is not so much as for the gray-scale images. Most of proposed colour image segmentation methods are the combination of the existing gray scale image segmentation method on the basis of different colour space. Commonly used for colour image segmentation methods are histogram threshold, feature space clustering, region–based approach, based on edge detection methods, fuzzy methods, artificial neural network approach, based on physical model methods, etc.

JSEG image segmentation:

Colour image with homogeneous region are segmented [5] with an algorithm to generate clusters in the colour space / class. One way to segment images with textures is to consider the spatial arrangement of pixels using a region-growing technique whereby a homogeneity mode is defined with pixels grouped in the segmented region. Furthermore, in order to segment texture images one must consider different scales of images. An unsupervised colour-texture regions segmentation algorithm is ideal for this purpose, since it tests the homogeneity of a given colour-texture pattern, which is computationally more feasible than model parameter estimation.

It deals with the following assumptions for the acquired image

- Image containing homogeneous colour-texture regions.
- Colour information is represented by quantized colours.
- Colours between two neighbouring regions are distinguishable.

The JSEG algorithm [1] segments images in the form of JPEG properly, without manual parameter adjustment for each image and simplifies texture and colour. Natural scene is segmented based on this approach. Here we are going to segment the

Satellites images in the form of RGB (files are in JPEG format). Segmentation with this algorithm passes through two major stages, namely colour space quantization (number reduction process of distinct colours in a given image), and hit rate regions with similar colour regions merging, as secondary stage.

In the first stage, the colour space is quantized with little perceptual degradation by using the quantization algorithm [7] with minimum colouring. Each colour is associated with a class. The original image pixels are replaced by classes to form the class maps (texture composition) for the next stage [10]. Before performing the hit rate regions, the J-image [2] – a class map for each windowed colour region, whose positive and negative values represent the edges and textures of the processing image- must be created with pixel values used as a similarity algorithm for the hit rate region. These values are called 'J-values' are calculated from a window placed on the quantized image, where the J-value belongs. Therefore, the two-stage division is justified through the difficult analysis of the colour similarity whital their distributions. The decoupling of these features (Colour similarity and spatial distribution) allows tractable algorithms development for each of the two processing stages.

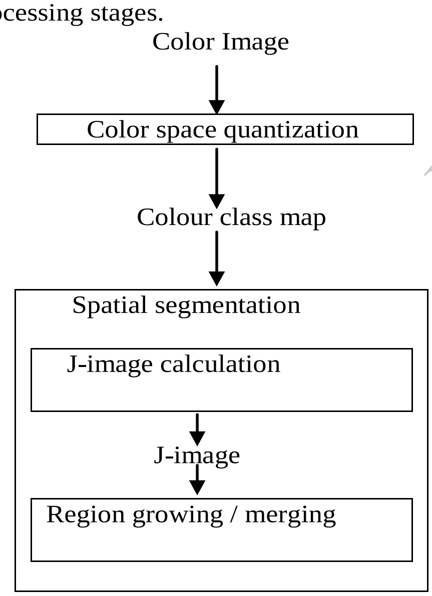

Fig.1 JSEG image segmentation Steps

Segmentation algorithm evaluation:

A good segmentation method is to extract representative colours differentiating neighbouring regions in the acquired image, as an unsupervised method. The colour quantization using peer group filtering is applied through perceptual weighting on individual pixels, to smooth the image and remove the existing noise. Then new values indicating the smoothness of the local areas are obtained, and a weight is assigned to each pixel, prioritizing textured areas to smooth areas. These areas are identified with a quantization vector to the pixel colours, based on General Lloyd Algorithm (GLA), which the perceptually uniform L*u*v colour space is adopted, presenting the overall distortion D:

$$D = \sum_i D_i = \sum_i \sum_n v(n) \,\|x(n) - c_i\|^2 \longrightarrow x(n) \in C_i \quad \text{...(1)}$$

And it is derived for

$$c_i = \frac{\sum v(n)x(n)}{\sum v(n)} \rightarrow x(n) \in C_i \quad \text{...........(2)}$$

where ci is the centroid of cluster Ci, x(n) and v(n) are the colour vector and the perceptual weight for pixel n. Di is the total distortion for Ci.

After clustering merging for colour quantization, a label is assigned for each quantized colour, representing a colour class for image pixels quantized to the same colour. The image pixel colors are replaced by their corresponding colour class labels, creating a class-map.

Segmented 1	Not Segmented 2
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Fig.2 Two different class-map representing three distinct classes of data points.

In the above figure, class-map 1 indicates three regions containing a single class of data points for segmentation process, and class-map 2 is not segmented indicating colour uniformity. The symbols (+, -, #) denotes the label values (J-value) for three distinct data points. All necessary segmentation information, after colour quantization, is extracted and relocated to a class-map. A specific region contains pixels from a colour class set, which is distributed in image regions. These regions, forming each one, a class-map has distributed points in all spatial data segments, corresponding a two-dimensional plane, and represents the Cartesian position vector (x, y). In order to calculate the J-value, Z is defined as the set of all points of quantized image, then z = (x, y) with z Ɛ Z and being 'm' the average in all Z elements. C is the number of classes obtained in the quantization. Then Z is classified into C classes, Zi are the elements of Z belonging to class i, where i = 1,.......,C, and 'mi' are the element averages in Zi.

$$m = \frac{1}{N} \sum_{z \varepsilon Z} Z \quad ....(3)$$

$$m_i = \frac{1}{N_i} \sum_{z \varepsilon Z} Z \quad ....(4)$$

The J- values are as follow

$$J = \frac{SB}{SW} = \frac{(ST - Sw)}{Sw} \quad ....(5)$$

$$\text{Where } S_T = \sum_{z \varepsilon Z} ||z - m||^2 \quad ....(6)$$

$$S_w = \sum_{i=1}^{c} * \sum_{z \varepsilon Z} ||z - mi||^2 \quad ....(7)$$

The parameter S_T represents the sum of quantized image points within the average in all Z elements. Thereby, the relation between S_B and S_W, denotes the measures of distances of this class relation, for arbitrary nonlinear class distribution [8]. J for higher values indicates with homogeneous colour regions. The distance and consequently, the J value, decrease for images with uniformly colour classes. Each segmented region could be recalculated, instead of the entire class-map, with new parameters adjustment for $\bar{J}$ average. J_k represents J calculated over region k, M_k is the number of points in region k, and N is the total number of points in the class-map, with all regions in class-map summation

$$\bar{J} = \frac{1}{N} \sum_k Mk\,Jk \quad .... (8)$$

For a fixed number of regions a criterion for J is intended for lower values

Spatial segmentation Algorithm:

The characteristics of the J-images allow us to use a region-growing method to segment the image. The following Fig.3 shows a flow chart of the steps in our spatial segmentation algorithm. Consider the original image as one initial region. The algorithm starts segments all the regions in the image at an initial large scale. It then repeats the same process on the newly segmented regions at the next smaller scale until the minimum specified scale is reached.

Valley determination:

A heuristic for the valley determination, presupposes a condition for initial regions to be determined as the pattern growing. These regions have the lowest J values (valleys).

As follows:

Calculate the standard deviation and the average of the local J values in the region, denoted by σ_J and μ_J, respectively.

Threshold for parameter above:

$$T_J = \mu_J + \sigma_J \quad ....(9)$$

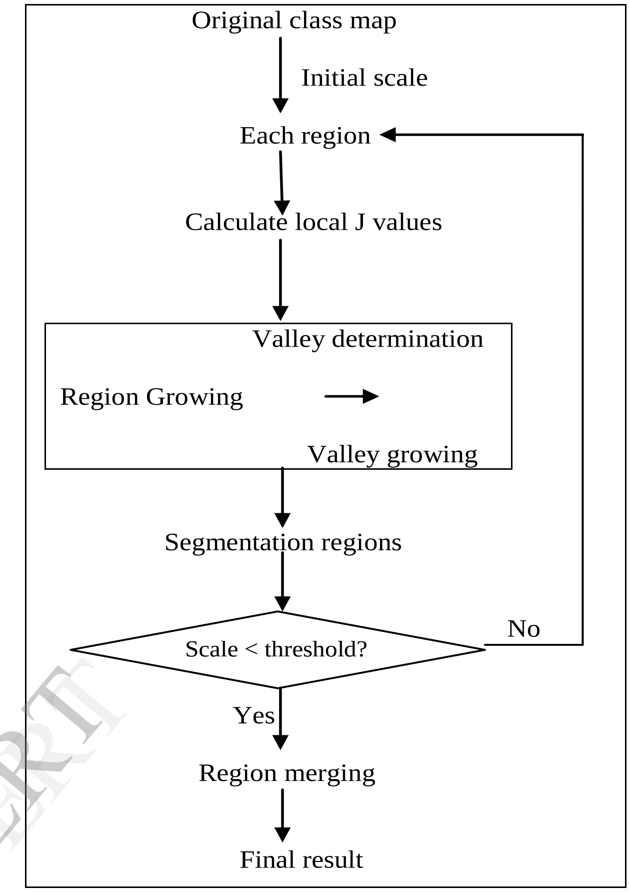

Fig.3 Flow- chart of the steps in spatial segmentation

The condition to candidate valley points for pixels with local J values is determined TJ >J. Connect the points based on the 4- connectivity and obtain the valleys.

a. For candidate valleys smaller than the spatial segmentation relation between scale and image size, they are denoted as valleys.
b. A preset parameter values [-0.6, -0.4, -0.2, 0, 0.2, 0.4] is given for variable a, which gives the most number of valleys.

Valley Growing:

The new regions are then grown from the valleys. It is slow to grow the valleys pixel by pixel. A faster approach is used in the implementation:

1. Remove "holes" in the valleys.
2. Average the local J values in the remaining unsegmented part of the region and connect pixels below the average to form growing areas. If a growing area is

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adjacent to one and only one valley, it is assigned to that valley.

3. Calculate local J values for the remaining pixels at the next smaller scale to more accurately locate the boundaries.
4. Grow the remaining pixels one by one at the smallest scale. Unclassified pixels at the valley boundaries are stored in a buffer. Each time, the pixel with the minimum local J value is assigned to its adjacent "valley" and the buffer is updated till all the pixels are classified.

Region Merge:

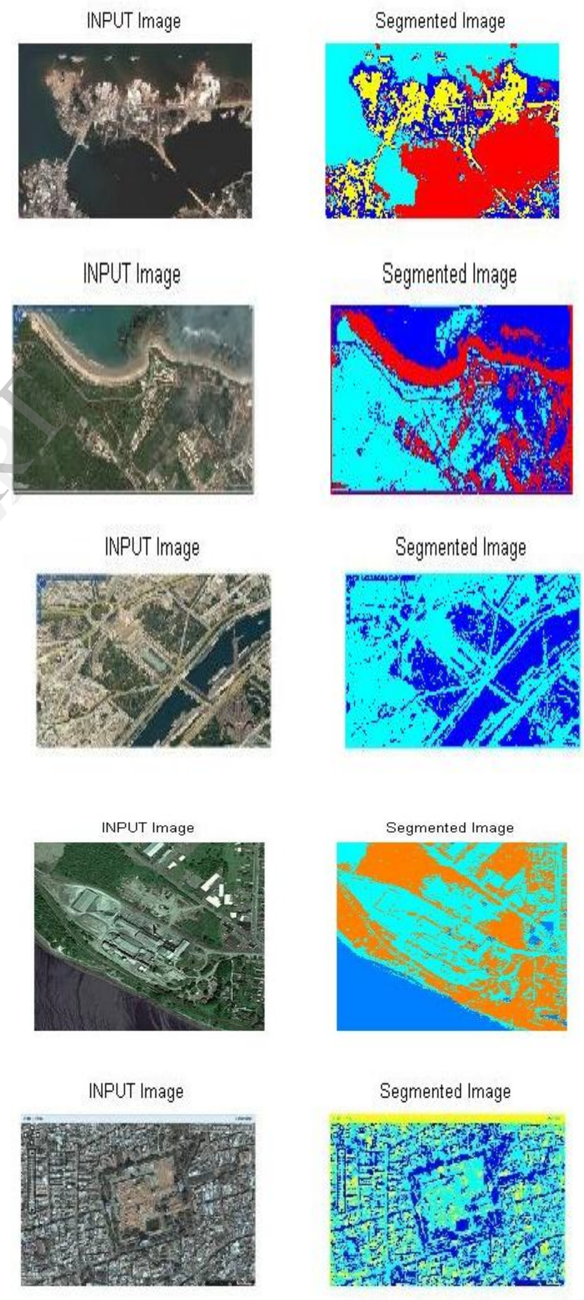
After region growing, an initial segmentation of the image is obtained. It often has over segmented regions. These regions are merged based on their colour similarity. The quantized colours are naturally colour histogram bins. The colour histogram features for each region are extracted and the distances between these features can be calculated. Since the colours are very coarsely quantizes, in this algorithm it is assumed that there are no correlation between the quantized colours. Therefore, a Euclidean distance measure is applied directly. An agglomerative method is used to merge the regions. First, distances between two neighbouring regions are calculated and stored in a distance table. The pair of regions with the minimum distance is merged together. The colour feature vector for the new region is calculated and the distance table is updated. The process continues until a maximum threshold for the distance is reached. After merging, the final segmentation results are obtained.

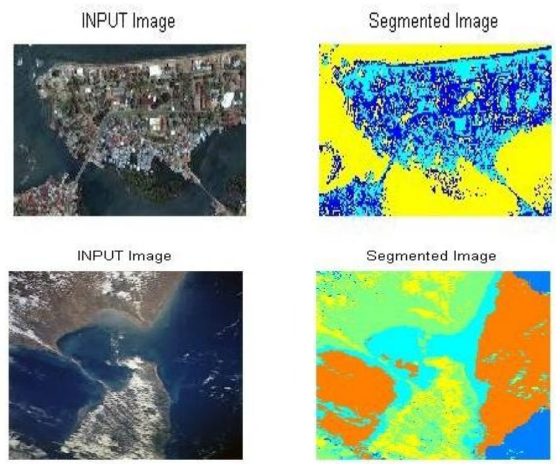
Algorithm for JSEG on Satellite Image:

1. Read the input image;
2. Convert RGB to L*a*b;
3. Find out the histogram for L*a*b;
4. Apply K-means algorithm;
5. Apply region growing algorithm;
6. Display the resultant object.

Experimental Results:

The JSEG algorithm [1] is tested on a variety of Satellite images. The following figures show the result of the segmentation on different Satellite images. Since system not support to display the raw Satellite Images, we take Satellite image as input image in the form of RGB. Segmented images are dimmed to show boundaries. It can be seen that the results are quite good. However, due to the lack of ground truth it is unable to perform any objective evaluation or comparison with other segmentation methods. The JSEG algorithm has 3 parameters that need to be specified by the user. The first one is a threshold for the colour quantization process. It determines the minimum distance between two quantized colours. The second one is the number of scales desired for the image. The last one is a threshold for region merging. These parameters are necessary because of the varying image characteristics in different applications. The algorithm works well on a variety of images using a fixed set of parameter values. Following Fig. shows some example of the Satellite images in the form of RGB processed without any parameter tuning on individual images.





Conclusion:

In this work, a new novel approach for colour image segmentation, called JSEG, is applied on Satellite Images. The segmentation consists of colour quantization and spatial segmentation. A criterion for "good" segmentation is proposed. Applying the criterion to local image windows result in J-images, which can be segmented using a multi-scale region growing method. Result shows that JSEG provides good segmentation on a variety of Satellite Images. JSEG segregate the object clearly as vegetation area, water, building, and road. JSEG shows that the segmentation results are much better than other existing approaches. Future works is handling the varying shades of an object due to illumination and segregate the boundaries of two neighbour regions clearly.

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