SEMIAUTOMATIC SEGMENTATION OF HIGH RESOLUTION IMAGERY WITH TEXTURE SEED REGION GROWING

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ABSTRACT:

High spatial resolution satellite imagery has become an important source of information for mapping and a great number of related applications. Region based segmentation of high resolution imagery is now considered a more suitable method than traditional per pixel classification techniques. Region growing is a classical method in image segmentation due to its simplicity and effectiveness in making using of spatial information among pixels. On the other hand, the automatic and optimal selection of the seeds of growing has been a key in the context. In order to take great advantage of human vision's capability of object recognition, this paper presents a semiautomatic segmentation scheme by which seed regions provided by human operator grow to their boundary separating the seed object and its background. The algorithm 'learns' texture measurement from the seed region and tries to expand the seed region till the grown region has maximal difference of texture property with the background while the in-class texture property is still consistent. We used a local binary pattern based texture measurement and tested the approach with a number of high resolution images to extract residential, forestry and different land coverage. The result shows its potential of practical utilization in analysis of high resolution imagery.

1. INTRODUCTION

With the fast pace of the development of earth observation and imaging technology, higher and higher spatial resolution imagery are piling up drastically. For instance, nowadays less than 1 meter per pixel resolution imagery has been acquired everyday by commercial satellite image vendors. With its short turnaround time and obviously richer information that could be extracted, high resolution remotely sensed imagery has become an important source of geospatial information as well as a great number of direct applications in nature resource, disaster management, urban planning, agriculture, forestry, topographic mapping etc. Automatic pixel classification is a vital technology in order to interpret and extract useful information from imagery. Traditional pixel classification method, including (supervised or unsupervised) classifiers such as Maximum Likelihood, K-Means, Multi-Layered Perceptrons and Fuzzy Adaptive Resonance Theory (ART) (Liu *et.al.*, 2006), achieved great success in classifying lower resolution imagery while showing weakness in separating objects from high resolution images (higher than 1m/pixel). This is because in a complex image scene, the distributions of pixel properties in the feature space demonstrate highly mixed characteristics, so that traditional statistic algorithm is luck of reliable tool to separate different features in the feature space. In the last decade, a so called Object-oriented method of analysis of high resolution imagery has received most of the attention from both research and industry (Blaschke 2010). In stead of dealing with 'pixels', the method is based on analysis of objects comprise of spatially neighboring pixels. The essential advantage of this method is that it makes use of the important spatial relations among pixels, which contain much information about objects of on the image. Towards object oriented image analysis, region based image segmentation is to partition an image into different regions based on their different properties. It is the basic technology in order to form different 'objects' for the further analysis. Region based image segmentation has been a very active area in recent years (Schiewe 2002, Hu *et.al* 2005, Mallinis *et.al* 2008, Wuest and Zhang 2009,).

In stead of focusing on automatic segmentation, this paper deals with a semiautomatic method by which a human operator gives initial 'seeds' to extract interested regions from an image. The rationales of the semiautomatic method stem from: (1) there is no magic automatic method or algorithm that can extract all objects with 100% correctness and completeness, if human intervene in advance (giving some 'seeds') can greatly improve the extraction accuracy, it will be a very useful tool in practice; (2) Not all land covers or objects on the image are of interest in many applications. Semi-automatically extracted objects can meet the need of lots of use cases. For instance, depending on the scenarios a user may

only be interested in pines trees (or residential areas, grass lands, water areas etc) on a specific image. In case of extracting limited type of objects, it will be sufficient enough that using a few mouse 'clicks' on the image one extracts those regions with ease.
In the next section, the general scheme of the propose method is given. Using the scheme, the texture region growing method is proposed in section 3. The method is inspired by The Hierarchical Split Merge Refinement (HSMR) segmentation Framework first proposed by Ojala and Pietikainen (1999). The deformation of the pixel refinement step of HSMR is adopted as the controlling mechanism of the proposed algorithm. After showing the testing examples in section 4, the conclusions and discussions are followed in the last.

2. FRAMEWORK OF SEMIAUTOMATIC REGION EXTRACTION BASED ON SEED REGION GROWING

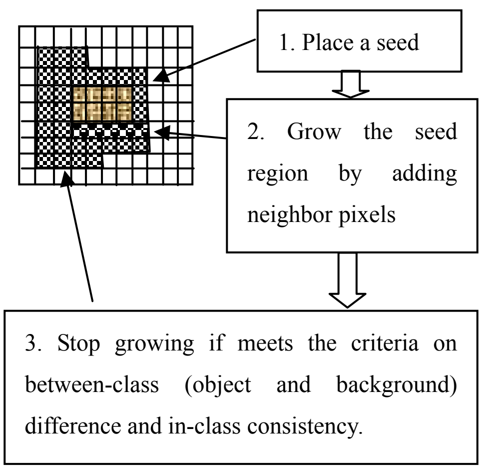


Figure 1. The workflow of semiautomatic region extraction

Among region based segmentation methods, seed growing is a frequently used strategy in which regions are formed by adding pixels into seed pixels or regions. A key to the success of the seed growing method is optimally selecting or locating the seeds on the image. Improper selection or location of the seeds results in incorrect or inaccurate results. In our semi-automatic scheme, the seed selection problem is eliminated by employing human visual inspection – we assume that the human operator identifies and locates the seeds optimally for the extraction of a specific region.

The general workflow of the proposed method is illustrated in Figure 1. The core of the method is the dynamic estimation of difference between the object region and the 'background' because it determines when the growing stops and so the object boundary. In the next section, a texture measurement called LBP/C (Ojala and Pietikainen 1999) is used for region pattern representation. How the region growing proceeds and stops also are described.

2. TEXTURE SEED REGION GROWING

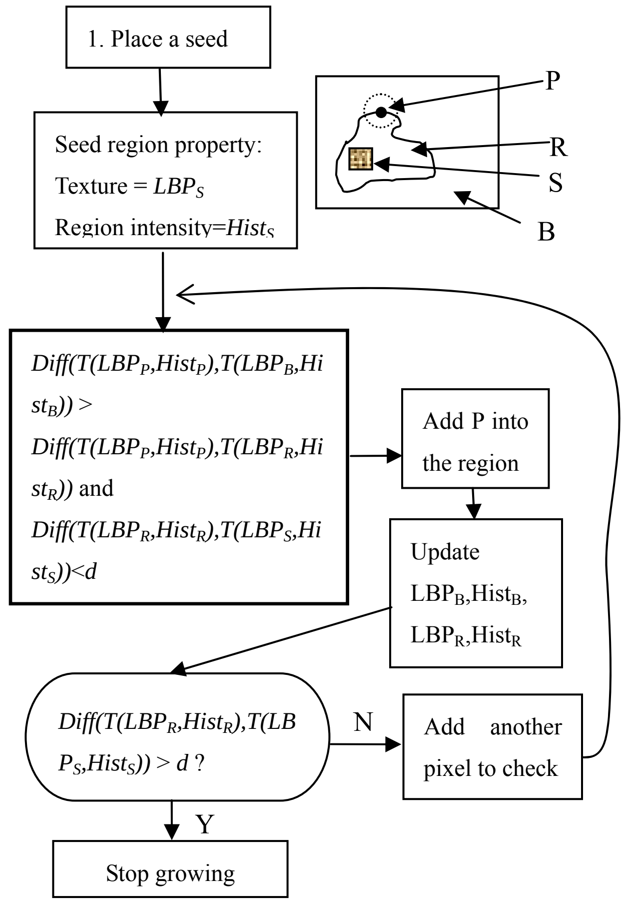


Figure 2. Texture seed region growing

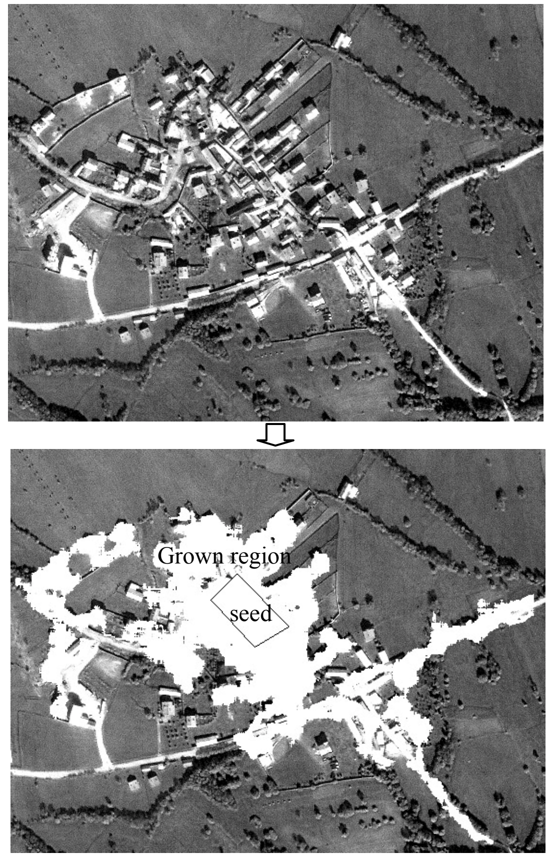
Based on the algorithm of image segmentation using adaptive multiple features integration proposed by Hu et.al (2005), the seed region growing algorithm is illustrated in Figure 2.

We donate P, S, R and B as a boundary pixel of the region, the original seed region, the current region in the growth and background which is the inversing area of the current region in the image, respectively. LBP_X, $Hist_X$ are the texture measurement of Local Binary Pattern and the intensity histogram of the specific region X. $T(LBP_X, Hist_X)$ measures the texture property of the specific region with its LBP and intensity distribution. How these two distributions are fused can be found in Hu et.al (2005). Function *Diff(.)* is modeled to evaluate the texture difference of the investigated regions. In case of P, we use a sub-region around the pixel – it can be the square image window centered by the pixel. The window size is usually 15-30 pixels. The basic idea of the method is that the algorithm dynamically estimates between-class (object and background) difference and in-class consistency in order to make the decision of adding or not adding a pixel into the region and stopping the growth.

4. TESTING RESULTS

Applying the proposed algorithm, we tested it using a number of high resolution images with at least 2.4m/pixel resolution. Figure 3 shows segmentation results of extracting forest/woody region and residential area. The seed regions are also shown.

a. Woody region extraction



b. Residential area

5. CONCLUSION AND FUTURE RESEARCH

Experimental results indicate that the proposed method is useful in semi-automatic extraction of interested texture regions, especially if the shape of the region is complex.

There are still several key aspects of the algorithm that needs to be improved. First, instead of using an empirical value *d*, the stopping criteria of region growth should be adaptively determined. In some cases, in-proper *d* leads to over-growth or under-growth of the region. Secondly, during the growth, for each boundary pixel the algorithm computes difference among sub-regions as described in section 3. This is very computationally expensive if the region is large. For example, to a region larger than 10000 by 10000 pixels the growth may take several minutes, this is unacceptable for a semiautomatic method because users usually want to see the instant response of the operation. An image pyramid strategy may be involved in order to speed up the growth by carrying out the growth by a top-down order on the different levels of the image pyramid. These two directions are the main focuses of our future research.

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