**IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)**
**ISSN 2321-8843**
**Vol. 1, Issue 5, Oct 2013, 9-14**


# PERFORMANCE EVALUATION OF ALGORITHMS FOR IMAGE SEGMENTATION

**AASHISH A. GADGIL**

Department of Electronics and Communication Engineering, Gogte Institute of Technology, Belgaum, Karnataka, India

## ABSTRACT

Image segmentation is one of the most important steps involved in performing higher level image processing, e.g. Medical Imaging (locate tumors, tissue volumes etc.), Face recognition, Video surveillance. A lot of researches have dedicated to this field because of its intrinsic dilemma, but there still remain a wide range of shortcomings in the current segmentation methods. If used in case of satellite imagery which contains tremendous data volume and very multifarious ground feature distributions, it will encounter even more difficulties in extracting meaningful and valuable patterns. In this paper, satellite imagery is classified into two types: the gray value and surface imagery, and then look for suitable segmentation methods. Various segmentation algorithms are implemented that are also illustrated and validated with typical applications on segmenting and extracting objects of interest from the images.

**KEYWORDS:** Medical Imaging, Video Surveillance, Gray Value or Surface Imagery

## INTRODUCTION

Image segmentation is one of the most important operations used in the fields of computer vision, digital signal processing and pattern recognition [1]. It converts original pixel-based imagery into more condensed and abstract forms which helps in pattern recognition, segmentation is time and again looked as the first step for other higher level image interpretation, e.g. Medical Imaging, Video surveillance etc. Depending on their pixel value distributions, imagery is generally divided into two types, gray value or surface imagery. Methods which are suitable for gray value images include different kind of histogram threshold methods, edge detection and spatial domain based methods (e.g., region growing, split-and-merge [2]). Methods used for surface imagery use statistical methods (e.g., autocorrelation, filtering template), signal processing methods (e.g., wavelet transformation [4], Gabor filtering [5]) and model based methods (e.g., Markov and Gibbs random fields, fractal models etc).

Even though the development of image segmentation spans more than several decades in which thousands of methods were proposed, a single method is suitable for all kinds of imagery, and vice versa. It’s because of its intrinsic predicament, and the main problems involved in current image segmentation methods are.

- Inaccessible from the vision mechanism. While research progresses on human vision mechanism, current segmentation methods are still isolated from the use of human eye, as a result of which more robust, mechanism needs to be implemented for real time and parallel segmentation mechanism.
- No human knowledge guidance. There will be inconsistent interpretations if only gray values or spatial context information is used in segmentation. Humans use very little knowledge beyond the image itself to segmentation image with their eyes. The guidance of prior knowledge is extremely important, that helps us to reduce the image uncertainty, and improves the quality and efficiency of auto-segmentation. Its unrealistic to search for an all-purpose segmentation method. Currently focuses should be concentrated on finding suitable methods for suitable imagery which makes it issue-oriented.

## SATELLITE IMAGE SEGMENTATION

Due to large data size and complicated ground feature distributions, it’s often more difficult to segment remotely sensed imagery. The Multi-band property of satellite imagery causes many segmentation methods suitable for single band imagery inapplicable; large volumes cause the computation complexity to rise rapidly which is unreachable by many methods designed only for small imagery.

Besides, too complicated ground feature distributions of satellite imagery also make it uneasy to segment or extract meaningful patterns with common image segmentation methods.

In order to introduce current state-of-the-art image segmentation methods into the field of information extraction from satellite imagery, my efforts include the follows.

- A lot of step-by-step segmentation wizards are designed and implemented to guide the users in their segmentation. As I have mentioned, not even one method is suitable for all kinds of imagery. With these wizards, guiding knowledge about the image and alternative methods are presented to the users, which help them to choose a best method, set the parameters, and iteratively get their satisfying results.
- Introduce prior knowledge in segmentations. One of the specificities of human visual segmentation is that it involves a lot of prior knowledge which is also why it often gets better results than computer programs. In this paper, I try to introduce domain knowledge into segmentations, which is supposed to improve the intelligence of the methods. For example, the selection of segmentation scales, clustering numbers, and the parameters of the pre, post-processes might be specified by users with our step-by-step wizards.
- Multi-scale integrating framework of segmentation methods is designed and implemented. Multi-scale is commonly an intrinsic characteristic of many natural and social phenomena. We thus need to develop multi-scale segmentation methods or integrate methods into a multi-scale way to extract interesting spatial patterns. Scale space theory gives us a theoretic foundation for multi-scale segmentations. According to this theory, people begin their visual segmentation of a scene with large scales, which indicates that their visual cells first catch the stimulus of large objects or background, form their skeletons, and then focus step by step on the details or sub-targets. In this paper, I try to implement the multi-scale segmentation framework starting from discriminating large spatial patterns with suitable methods to obtain the global spatial context, which will then help to extract more detailed features with other segmentation methods.

## INTEGRATION OF METHODS

In this paper, I have tried to integrate current state of art segmentation methods into a unified multi-scale segmentation structure to bring forth their respective advantages. Such structure will help to select suitable methods for suitable targets.

Besides, with different image resolutions, different ground objects segmented in different scales, large scale objects might offer spatial contextual knowledge for segmentations in other finer scales Figure 1.

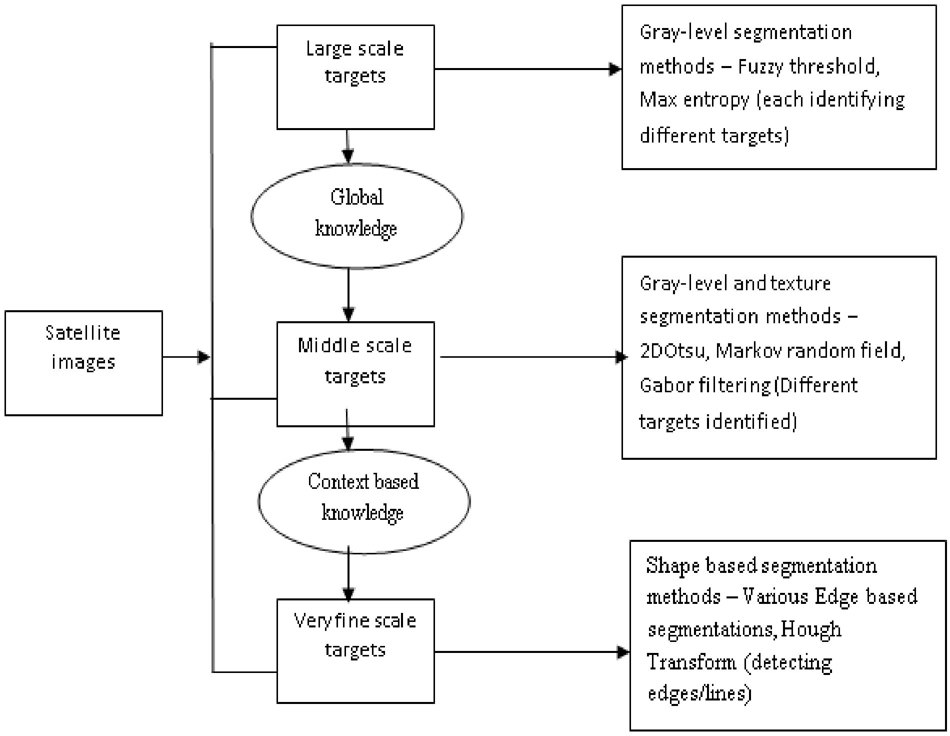



**Figure 1: An Integration Structure of Segmentation Methods**

**Diverse Methods**

For intensity images (images comprised of point-wise intensity levels) there four popular segmentation approaches: edge-based methods, region-based techniques, threshold techniques, and connectivity-preserving methods.

Threshold techniques make decisions based on local pixel information and are effective when the intensity levels of the objects fall squarely outside the range of levels in the background. As spatial information is ignored, blurred region boundaries may cause a lot of problems.

Edge-based methods use contour detection. They have problems in connecting together broken contour lines and hence are prone to failure in the presence of blurring.

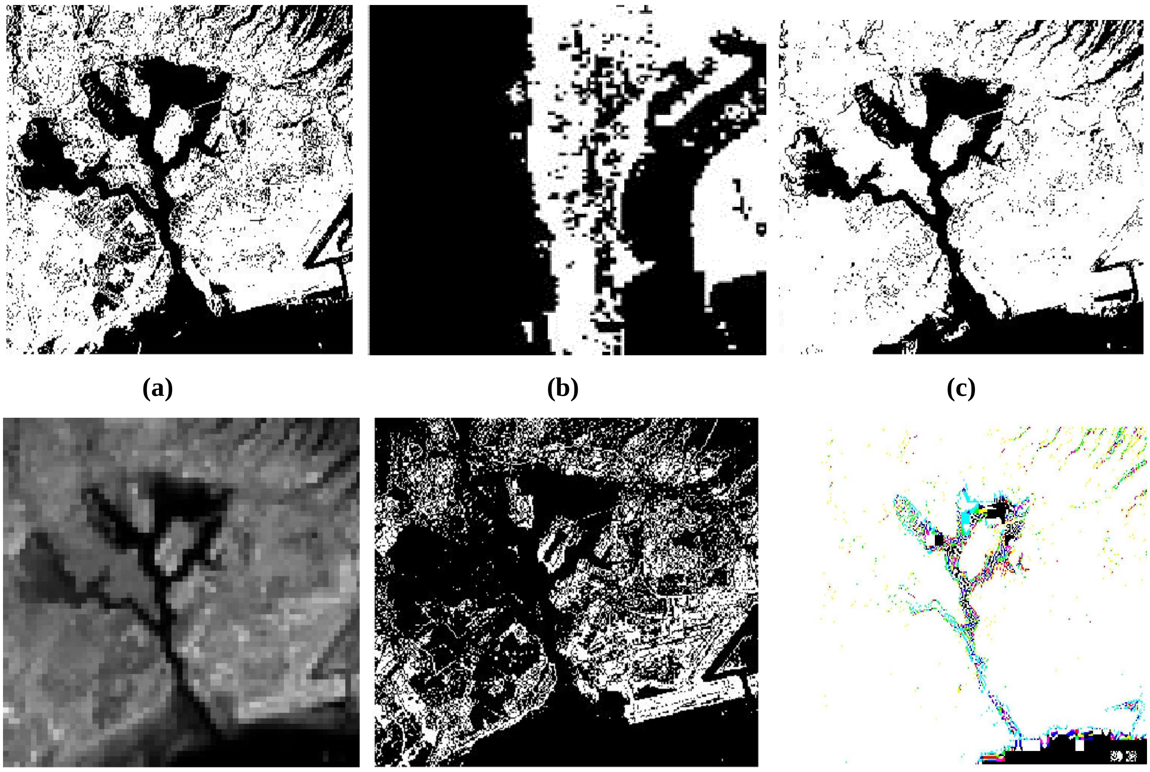
A region-based method partitions an image into connected regions by grouping neighboring pixels of similar intensity levels. The adjacent regions are then merged under some criterion involving perhaps homogeneity or sharpness of region boundaries. A rigid criterion will create fragmentation whereas lenient ones overlook blurred boundaries and overmerge.

A connectivity-preserving relaxation-based segmentation method, generally referred to as the active contour model, starts with an initial boundary shape represented in the form of spline curves, and then iteratively modifies it by applying various shrink/expansion operations according to some energy function. Even though the energy-minimizing model is not new, coupling it with the maintenance of an “elastic” contour model gives it an interesting new twist. As usual with such methods, getting trapped into a local minimum is a risk against which one must guard; this is no easy task.

In order to validate the structure, I have already implemented more than 6 segmentation methods including Hough transformation, Otsu2D, Gabor filtering, improved max entropy [6], Markov random field model [7][8], etc. With comparisons on segmenting a lot of satellite imagery, limitations and capabilities of these methods can be found out. Table 1 and Figure 2 are one of the experimental results of segmenting a pearl harbor image obtained from a satellite.

**Table 1: Methods Used for Segmenting Different Harbor Images**

| Method | Time Consumed | Results | Performance Evaluation |
|---|---|---|---|
| 2D Otsu | 5 seconds | Figure 2 (a) | Target is separated with speckles |
| Max entropy | 6 seconds | Figure 2 (b) | Target is partly separated |
| Markov random field | 9 seconds | Figure 2 (c) | Target is separated from background |
| Gabor filtering | 18 seconds | Figure 2 (d) | Segmentation with coarse result |
| Fuzzy threshold with genetic algorithm | 22 seconds | Figure 2 (e) | The main target is partly separated with speckles |
| Moment method | 37 seconds | Figure 2 (f) | The main target is separated with coarse result and many speckles |



**(a)** **(b)** **(c)**

**(d)** **(e)** **(f)**

**Figure 2: Segmentation Methods Implemented**

## ILLUSTRATION ANALYSES

### Large Scale Target Segmentation Using Max Entropy Method

With the guidance of the proposed integrating structure, Max entropy method is applied to segment a harbor from a high spatial resolution satellite. Because it is only a simple gray value threshold method but with relatively fast speed, it can get good results in large scale regional segmentation. If successful, it could further be applied as a pre-processing of other finer scale segmentations, providing the global spatial contextual knowledge. In this experiment, I have tried to separate land and water and iteratively separate the sands from the land with inputs of different number of classes.

The segmentation results in Figure 3 illustrates that land and water are successfully discriminated, with some errors of classifying the land with dark tones into water. This seems to be unavoidable if without any further auxiliary processing. With more number of classes, the sands (shoals) are totally separated, with some mistakes of some water with relatively bright tones are classified into sands. It can be found that max entropy method can segment large regions very fast speed as well as keep edges of targets and background. Although with its deficiencies, max entropy method is not bad in segmenting this kind of gray value satellite imagery. It can be used as a starting method for the initial, large scale segmentation of imagery to get global spatial contextual knowledge.

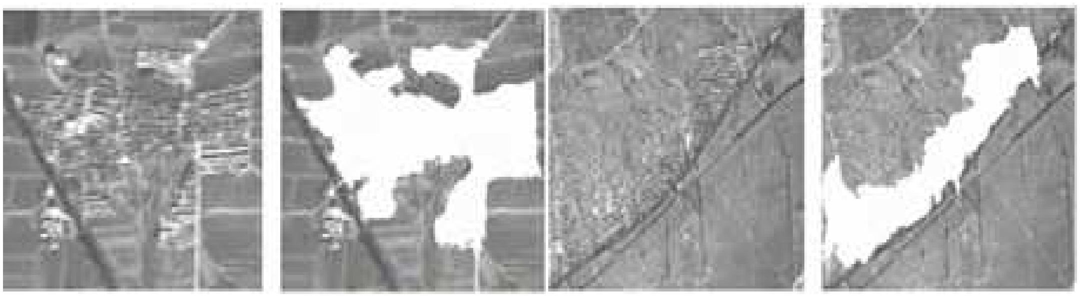
**(a) (b) (c)**

**Figure 3: Segmentation of Harbor a) Experimental Area b, c) Segmentation Depending on Number of Classes Considered**

**Middle Scale Target Segmentation with Gabor Filtering**

Gabor filtering segments an image with creating a group of filtering templates to extract features with different orientations and scales and then classify them. For images with sufficient oriental textual information, it can get relatively good results. Figure 4 illustrates some results of extracting some middle scale targets, residential areas in Yanqing, Beijing from the Beijing-1 imagery.

To balance the efficiency and precision of this algorithm, 12 texture features are extracted with 3 scales, 4 orientations, and the features are classified into 2 classes. Figure 4(b), 4(d) show the texture segmentation capability of this method for middle scale targets.



**(a) (b) (c) (d)**

**Figure 4: Segmentation of Residential Areas [10]: a, b) Experimental Area 1 and its Segmented Image c, d) Experimental Area 2 and its Segmented Image**

## CONCLUSIONS

Image segmentation is a key and difficult task for image interpretation with a lot of problems unresolved. This paper introduces some work dedicated to this field, which includes the efforts to involve visual expertise knowledge in segmentation, integrate current state of art methods into a universal structure to adapt to different applications, etc. Although with some progresses, the studies are just getting started. More attentions can be applied to the deeper, seamless integration of geographical knowledge, multi-scale segmentation structure, and parallel segmentation strategy to notably increase the effect and efficiency of segmentation methods for information mining from satellite imagery.

## REFERENCES

1. Y.J. Zhang. Image segmentation. Beijing: Science Press, 2001
2. S.Y. Chen, W.C. Lin, and C.T Chen. Split & merge image segmentation based on localized feature analysis and statistical tests. CVGIP: GMIP, 1991, 53(5):457-475
3. R.M. Haralick, K. Shanmugam and I. Dinstein. Features of textures for image classification. IEEE Transactions on Systems, Man, and Cybernetics, 1973, SMC-3, 611-621
4. J. Morlet, G. Arens, E. Foureau, and D. Giard. The Wave propagation and sampling theory--Part II: Sampling theory and complex waves. Geophysics, 1982, 47(2): 221-236
5. D. Dunn, W.E. Higgins and J. Wakeley. Segmentation of Texture using 2-D Gabor Elementary Functions. IEEE Trans. Pattern Anal. Machine Intell., 1994, 16(2):130-149
6. D.L. Zhou, Q. Pan, H.C. Zhang, and G.Z. Dai. Maximum Entropy Thresholding Algorithm. Journal of software, 2001,12(9):1420-1422
7. Y. Dong, B.C. Forester and A. K. Milne. Segmentation of radar imagery using the Gaussian Markov random field model. Int. J. Remote Sensing, 1999, 20(8):1617-1639
8. S.H. Zhou. Unsupervised Texture Segmentation. Via. Gaussian Markov Random Field (GMRF) Model. URL: http://www.cfar.umd.edu/~shaohua/papers/739j_texseg_report.doc, 2001, 368916
9. Yatharth Saraf. Algorithms for Image Segmentation. BITS, Pilani. 2006
10. Min Wang, Integration of Image Segmentation Methods for Information Extraction from Remotely Sensed Imagery, IEEE Congress on Image and Signal Processing 2008, 682-686