Evaluation of Object-based Image Analysis Softwares for segmentation in Remote Sensing Applications

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Abstract

With high resolution satellite images, object-based image analysis has dwarfed the impact of pixel-based analysis methods. Segmentation plays a pivotal role in the performance of object-oriented methods like change detection, feature extraction. We have conducted a study to compare some of the segmentation softwares of different categories. Softwares were tested on low resolution (10 m) multispectral and high resolution (1m) panchromatic images under various parameter permutations. Reference-based metrics were used to assess their performance in terms user expectations like ease & availability, fragmentation, time, fidelity.
Keywords: segmentation, open source, softwares, OBIA

1 Introduction

There are several Object Based Image Analysis [1] (OBIA) softwares available in the market facilitating different algorithms. Most GIS softwares offer OBIA packages since topological and shape information extracted can be integrated as thematic layers. The softwares surveyed in this article are:

- eCognition
- Orfeo Toolbox
- Ilastik
- Spring
- MultiSpec
- Ilwis

The survey includes popularly used softwares amongst researchers and students. However, softwares like PCI Geomatics, geoDMA etc also have OBIA capabilities and the survey will be extended in future to assess these softwares as well.

2 Parameters and methods of evaluation

To assess the degree of under- or over-segmentation in the image, some metrics [3], [4]were used as shown in Table 1 .

Table 1 Metrics for assessing segmentation quality

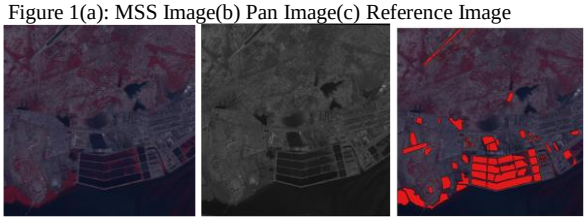
Name	Formulae	Preferred values
Fragmentation Index(FI)	$FRAG = \frac{1}{1 + p_1 \lvert T_N - A_N \rvert^q}$	~ 1
Area Fit Index (AFI)	$AFI = \frac{A_{reference} - A_{largestsegment}}{A_{reference}}$	~0
Avg. Area Diff. (AAD)	$AAD = \frac{\sum (A_{reference} - A_{largestsegment})}{Number\ of\ reference\ objects}$	~0
Avg. Perimeter Diff. (APD)	$AAD = \frac{\sum (P_{reference} - P_{largestsegment})}{Number\ of\ reference objects}$	~0

T_N is object count and A_N is no. of regions in the reference; p & q are scaling parameters, $A_{reference} - A_{largestsegment}$, $P_{reference}, P_{largestsegment}$ are area & perimeter of reference and largest segment within the area covered by the reference object.

3 Data Sets Used:

The test site was located in Mumbai, India (18.952° N, 72.8777° E). A subset of the test image is shown in Figure 1(a) & Figure 1(b). For evaluation, different regions were digitized on the reference image using QGIS 2.16 and reference vector (shape) file was generated which consisted of polygon features (marked in red, shown in Figure. 1(c)).

Figure 1(a): MSS Image(b) Pan Image(c) Reference Image



4 About the softwares

The study has categorized the softwares as: commercial, free and open source. Popularly used COTS software for OBIA includes eCognition and PCA Geomatica. Two freeware softwares were tested in the study, MultiSpec and SPRING. MultiSpec has capabilities like format handling, visualization, classification, etc. SPRING uses bject-oriented data model and region-growing segmentation. Three open source softwares were tested. Orfeo ToolBox (OTB) is an open-source project for remote sensing which can be integrated in QGIS. Segmentation algorithms in the toolbox include watershed, meanshift, k-means etc. ILWIS is integrated software with raster & vector processing capabilities. ilastik is a user-friendly tool for interactive workflow framework for image classification, segmentation & analysis. Fundamental

differences between all these softwares are discussed in Table 2.

Table 2 Comparison of softwares (fundamental parameters)

	Developer	Algorithm	Inputs	Availability	Formats
eCognition	Definiens Imaging	Multi resolution	3	Commercial	Raster, Vector
ilastik	Uni.of eidelberg.	Watershed	3	Open-Source	Raster
Multispec	Purdue University	Clustering	5	Freeware	Raster
SPRING 4.0	INPE, Brazil	Region Growing	2	Freeware	Raster
Orfeo	CNES	Watershed Mean shift Edison	>5	Open-Source	Raster, Shape
ILWIS	ITC	Clustering	2	Open-Source	Raster

5 Results & Discussion

Segmentation results for all software are shown in Table 3. eCognition can segment images at multiple resolutions using three parameters: scale, color and shape. Higher values for the scale parameter result in larger image objects. Weights are can be adjusted to negotiate between color or shape homogeneity for different sensor images. eCognition has the highest value of FI with very low values of AFI, AAD, APD which shows that it produces optimal number of segments(see Figure.2(a)).

Table 3 Quantitative comparison of software (in terms of time, feature count and metrics-based)

	eCognition Developer	Ilastik	Multispec	SPRING 4.0	Orfeo	ILWIS
AFI	0.96	2.01	0.78	0.07	0.29	0.07
AAD	1.52	12.29	9.32	34.35	55.00	74.63
APD	0.25	179.61	5.52	15.35	818.63	5.44
FI	0.56	0.13	0.18	0.09	0.07	0.01
Time(in mins)	4.63	18	30	8	0.8	
Object count	241	1,020	586	12,844	57,569	4,68,110

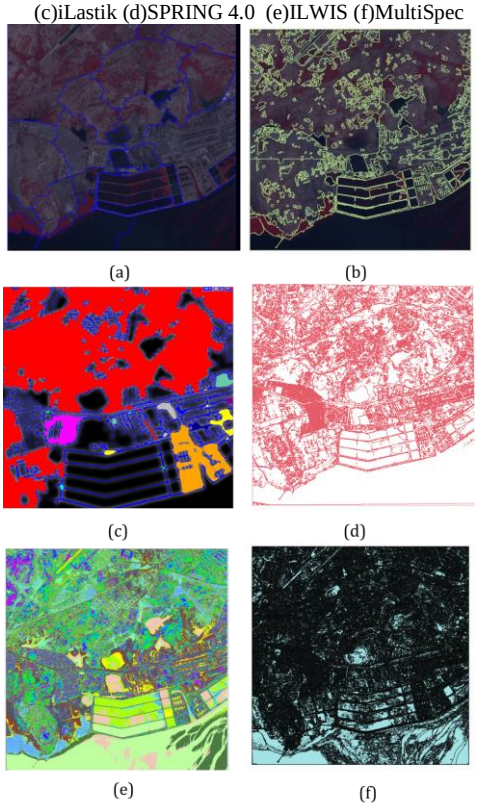
Unlike eCognition, Orfeo suffers from oversegmentation which is difficult to control if proper parameter values are not known. The segmented outputs are shown in Figure.2(b). Higher values of AFI, AAD & APD prove the same.

Segmentation of iLastik software is for medical applications. Thus, results were not appreciable (under-segmented) for satellite imagery as seen by higher values of AFI and negative values of AAD & APD . Spring segmentation is patchy and sporadic as evident from Table 2 & Figure 2(d).

Ilwis performs segmentation based on clustering technique. Maximum values of AFI show that it greatly suffers from oversegmentation.

Multispec has single pass and iterative ISODATA clustering. Multispec is simple to follow and gives fast results with good control over the cluster size(Figure 2(f)). It has the second highest value of FI showing that it is capable of controlling over-/under-segmentation.

Figure 2Segmentation as seen in (a)eCognition (b) Orfeo Toolbox (c)iLastik (d)SPRING 4.0 (e)ILWIS (f)MultiSpec



Refer to Figure 3 .With highest FI and other measures close to zero, eCognition gave best performance. ILWIS showed maximum oversegmentation. Under-segmentation is responsible for the negative values of AFI in iLastik.

6 Conclusion

Different commercial, open source and free softwares were analyzed in this study. Spring, Orfeo and Ilwis suffer from over segmentation. iLastik suffers from under-segmentation & has given better performance in biomedical field. Multispec has only ISODATA clustering method for segmentation but in comparison to others, it gives decent. eCognition uses realistic parameters like scale, color/ shape homogeneity. Thus, when it comes to preferring segmentation for spectrally rich vs spatially rich images, eCognition offers maximum possibilities.

7 References

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Figure 3 Graphical representation of scaled quantitative measures for comparison of the softwares