OBJECT ORIENTED ANALYSIS FOR CHANGE DETECTION

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Abstract

We compared an object-oriented approach to change labeling with a more traditional pixel-based routine using the enhanced wetness difference index derived from a multitemporal sequence of Landsat TM/ETM+ data acquired over the foothills of Alberta. During the period of observation, the landscape was subject to rapid change on a variety of fronts, including forestry, mining, oil and gas, and transportation, creating a compelling change detection challenge. The object oriented approach detected the various change categories with an overall accuracy of 84% (Kappa 0.69) compared to 59% (Kappa 0.48) for the pixel-based routine. The results of this preliminary analysis suggest that image segmentation has several important advantages over pixel-based techniques, and may eventually form the foundation for a highly efficient change detection methodology.

Introduction

The central goal of most technical research in remote sensing is to develop a standardized set of procedures for the efficient extraction of information from widely-available digital data. In striving to achieve this goal, many analysts have come to recognize the limitations of pixel-based image processing routines, particularly with respect to information in the spatial domain. As object-based image analysis software become more widely available, it is likely that the ‘standard’ procedures for performing many common information extraction routines will be re-evaluated.

This work reports on a preliminary study that compared a traditional pixel-based method of change labeling with an object-oriented classification approach using the software package eCognition. The pixel-based method consisted of a series of decision rules applied in a GIS environment: a technique that is limited in its ability to incorporate spatial information. We hypothesized that eCognition – a spatially sophisticated software package that focuses on object-based processing – would provide a better platform for labeling change features acquired from image differencing.

Study Area and Data Set

The study area is located in the Rocky Mountain foothills east of Jasper National Park near Hinton, Alberta. The region is composed of primarily spruce, pine and aspen forests in a moderate to high elevation area (1100–1400 m above sea level). In addition to natural processes, the area is subject to intensive anthropogenic change surrounding a variety of resource extraction activities, including forestry, coal, natural gas and oil (Schnieder, 2001).

Based on previous experience regarding the rate of change on the landscape, we elected to perform our analysis over three year period. Our intention was to capture a significant amount and variety of change with which to evaluate each technique. Remote sensing data consisted of an August 29, 1998 Landsat TM image (path 44, row 23) and an ETM+ image of the same area from September 14, 2001.

Methodology

In order to enable sound multidate comparisons, both images were subject to geometric and radiometric correction. A 100m provincial DEM was resampled to 30m and used for orthorectification. The images were converted to top-of-atmosphere reflectance to correct for illumination effects, and radiometrically matched to one another based on regression of pseudo-invariant features (Hall *et al.*, 1988).

Both images underwent a tasselled cap transformation (Crist and Cicone, 1984) and a 'change' image was acquired using the enhanced wetness difference index (Franklin *et al.*, 2001).

We compared two methods for labelling the change image. The first – pixel-based – technique was based on the following binary decision criterion performed in ArcView 3.2:

Wells
- Within 250m of Road
- Area less than 5 hectares

Cut blocks
- Area greater than 5 hectares
- Not including Mine Site

Mine Site
- Within 250m of existing mine

The alternative object-based change labeling was performed by classifying the change image in eCognition 3.0. eCognition calculates a large number of object-based 'features' – statistical characteristics of spatial data – that become available for subsequent classification. In order to select from the more than 50 features available, we performed a regression tree analysis with known training polygons to identify the combination best suited for this appliation: Length, Width, Shape Index, Standard Deviation, and Y

Center. These features were used to create membership functions that formed the basis of the change.

Accuracy assessment of both products was performed on a random sample of 250 points, derived from photo interpretation and field experience.

Results and Discussion

The results of the pixel-based change labeling product are shown in Table 1; the object-oriented product in Table 2. Since accuracy analysis in eCognition is object-based, the pixel count reported in the confusion matrix are inflated. However, the change features used in both accuracy assessment exercises were the same, so preliminary comparisons should be relevant.

Table 1: Confusion matrix of pixel-based change product. Kappa statistic is 0.48.

	Reference Data						
	Cut Block	Road	Mine Site	Well Site	No Change	**Total**	**User's (%)**
Cut Block	42	8	16	0	0	**66**	**64**
Road	10	7	2	9	0	**28**	**25**
Mine Site	7	2	19	0	0	**28**	**68**
Well Site	1	7	0	26	0	**34**	**76**
No Change	0	24	3	14	53	**94**	**56**
Total	**60**	**48**	**40**	**49**	**53**	**250**	
Producer's (%)	**70**	**14**	**48**	**53**	**100**	**Overall: 58%**	

Table 2: Confusion matrix of object-based change product. Kappa statistic is 0.69.

	Reference Data						
	Cut Block	Road	Mine Site	Well Site	No Change	**Total**	**User's (%)**
Cut Block	12967	830	0	37	147	**13981**	**90**
Road	286	2752	0	17	211	**3266**	**66**
Mine Site	433	0	1408	0	0	**1841**	**97**
Well Site	134	0	17	24	0	**175**	**21**
No Change	591	584	22	36	918	**2151**	**72**
Total	**14411**	**4166**	**1447**	**114**	**1276**	**21414**	
Producer's (%)	**93**	**84**	**76**	**13**	**42**	**Overall: 84%**	

The pixel-based decision rule produced a change map with an overall accuracy of 58% (Kappa 0.48). Areas that did not undergo change were correctly labelled (100% producer's; 94% user's), but the accuracy of the remaining 'change' classes ranged from 14% to 70%. Roads in particular were very poorly discriminated (14% producer's; 25% user's), with substantial confusion with nearly all other change categories. Roads are distinguished on imagery by their shape – long and skinny – and so are not well labelled by pixel-based routines. The object-based technique, by contrast, separated roads much better (84% producer's; 66% user), due to the ability to incorporate complex spatial

features such as Shape Index, Length, and Width. Roads in the object-based product were occasionally confused with cut blocks and no change features. The reason for this has more to do with the quality of the segmentation than the actual change labelling. The segmentation in eCognition is controlled by a complex series of parameters; good segmentation products require substantial number of iterations. This problem is particularly evident in the Well Site category: the poorest-performing category in the object-based product (13% producer's; 21% user's). Objects in this category are extremely small, and were not well distinguished in the image objects used in this study. A better segmentation would likely produce better results. Overall, however, the object-based technique performed much better, with an overall accuracy of 84% (Kappa 0.69) with individual class accuracies (apart from well sites) generally in the 70-90% range.

Conclusions

The drawback of pixel-based image processing routines is the relatively unsophisticated use of spatial information. Object-oriented approaches may offer a better alternative for many standard image processing tasks. A preliminary analysis of change detection over a fast-changing forested scene in the foothills of Alberta showed that an object-oriented approach to labeling various categories of anthropogenic change worked better overall than a pixel-based technique relying on less sophisticated spatial operators. Future work on this subject will focus on deriving more suitable segmentation products that preserve smaller change features.

References

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