Object oriented implementation monitoring method of zone feature in land consolidation engineering using SPOT 5 imagery

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Abstract: Land consolidation is an effective activity realizing the sustainable utilization of land use, and implementation monitoring of zone type land consolidation engineering. Funded by National High Technology Research and Development Program of China, an object oriented monitoring method is produced in this research. Object correlation images(OCIs) are used to measure if a zonal objects is consolidated (i. e., changed). There are three correction parameters are used in this study: correlation, slope and intercept in correction analysis process, and spectral and textural (4 Grey Level Co-occurrence matrix (GLCM) features such as Homogeneity, Contrast, Angular second moment, Entropy) information are used in caculation of objects correction value. This approach consists in three phases: (1) multi-resulition image segmentation, (2) correlation analysis of two phase remote sensing images, and (3) implementation monitoring based on segmented correction results. Firstly,the temote sensing images before and after land consolidation are partitioned into objects using multi-resolution segmentation method. Secondly, correlation analysis is done between these images. Finally, focused on these regions, implementation monitoring is done based on the comparability of image objects in the same area resulting from these two phase remote sensing images. Accuracy assessment results indicate that this method can be used to monitor land consolidation engineering implementation status, total accuracy up to 86.30%.

Key-Words: Object oriented, land consolidation engineering, implementation monitoring, object correlation images (OCIs), image segmentation, Fangshan district

1 Introduction

Land is a finite, non-reproducible consumption resource held as a source of livelihood and a financial security transferred as wealth across generations[1-2]. However, for multiple reasons such as family-based contracted responsibility system in China, topography , scattered habitat, demographic pressure on land resources etc., farm land in China is divided into many small farms,scattered over numerous non-contiguous plots[3-4]. This situation is unfavourable for agricultural sustainable development of China. Therefore people in China start engaging in land consolidation. Land consolidation is is a standard tool for ensuring rural development and for increasing land use effectiveness, this term comprises all land reallocation and corresponding subsequent measures, which are aimed at improving the efficiency of agriculture and forest management and increasing the potential for rural development. Land consolidation is a worldwide phenomenon[5-6] , which is developed comprehensivly in Germany, China, Russia, Japan, Australia, Egypt, India, Hungary etc. Land consolidation in practice consists of various redevelopment and structural measures: rearrangement and/or putting together of different,distributed land units, removal of terraces and defiles, construction of rural roads, restructuring of local streams, soil melioration,e.g.drainage, increasing water storage capacity within agricultural areas, nature conservation measures[7]. Several studies indicate that land consolidation may improve land productivity, labor productivity[8] and possibly also the total factor productivity if it induces and enhances technical progress and increases scale economies[9-10]. Along with the worldwide implementation of land consolidation, many new scientific issues to be solved urgently have emerged, particularly implementation monitoring of zone type land consolidation engineering. Survey and validation in field hold vast man power, financial resources and time consumption, it need advanced science and technology to monitor land consolidation engineering implementation status to ensuring the efficiency of land consolidation project and scientific level.

Remote sensing, especially high spatial resolution multispectral imagery from satellite and aerial sensors(e.g. IKONOS from GeoEye, Inc., QuickBird from DigitalGlobe, Inc., ADS40 from Leica Geosystems, Inc.), is an effective way to acquire large area land use information in a short time, which can be used in land consolidation engineering implementation monitoring. The goal of land consolidation implementation monitoring is to (1) finding the geographic location of consolidated areas when compraing two (or more) dates of imagery, (2) identify the land use type change if it is possible (e. g. sloping wasteland to cultivated land, abandoned beach to cultivated land, segmental land to large scale land), (3) quantify the area of land consolidation (e. g. 100 ha). In certain degree, land consolidation implementation monitoring is a kinds of land use/cover change detection. Generally speaking, change detection involves the analysis of two co-registered multi-spectral images acquired in the same geographical area at two different times; it can be performed both by an unsupervised (Change Vector Analysis(CVA), Image Rationing and Vegetation Index Differencing) and a supervised (Post Classification Comparison(PCC)) approach [11-14].

Compared with perfect hardware techniques of remote sensing sensor, post-processing techniques of remote sensing image develop late relatively[15]. Traditional pixel-based land consolidation engineering implementation monitoring method results in severe *pepper-and-salt effect* in engineering implementation monitoring result[16]. Fortunately, object oriented monitoring method depicts land use types in parcels, which refrain zone type land consolidation engineering information extraction from severe pepper-and-salt effect. Object oriented method is based on segmented image objects, not single pixels, which subdivides the image into meaningful homogeneous regions based not only on spectral properties but also on shape, texture, size, and other topological features [17-18]. So the sample textural, spatial and hierarchical information of high resolution remote sensing image can be used in object oriented method. This research is about object oriented implementation monitoring method of zone features in land consolidation projects using SPOT 5 imagery, which includes two vital techniques: generation of object correlation images and neighborhood correlation images (i. e. image segmentation), implementation monitoring based on segmented parcels[19-20].

2 Study area and data source

The study area is Qinglong Hu town, which is a demonstration area of land consolidation in Beijing. It is located in south-west of Fangshan district, topography of which is complicated and the area of mountainous area, Regional hills and plain are equal. And it is at the confluence of the Qinglong Hu, covering approximately 95.78 km^2. The geographic coordinates (latitude/longitude) approximately range from 116° 02’ 50’’ E, 39° 48’ 43’’ N to 116° 04’ 00’’ E, 39° 49’ 33’’ N, the location and image of study area are shown in Fig. 1. Land cover types are cultivated land, garden, forest land, residual land, water body and unused land etc.

Fig. 1 Location and SPOT 5 image (2.5m) of Study Area (QinglongHu town, Fangshan district, Beijing, China)

Land consolidation is done between 2001 to 2003 in study area. So these two SPOT 5 images, acquired on 12 October, 2002 and 29 September, 2006, without any clouds/hazes, are used in this study, which are the images before and after land consolidation implementation and can be used to monitor engineering implementation status. A SPOT 5 image has four multi-spectral bands (i.e. near-infrared(NIR), red, green, and Short Waved-length Infrared) with 10-metre spatial resolution and one panchromatic band with 2.5-metre spatial resolution. The first step of image preprocessing is geometric correction. There are 46 geometric correction sampling are collected in sum, which are distrrbuted well-proportioned in the whole image. Both dates of imagery were geo-referenced to a Transverse Mercator projection and Krasovsky spheroid with an RMSE of 1 pixel. It was necessary to radiometrically normalize the multiple dates of remote sensor data even though they were obtained on near anniversary dates. Field work is done to do accuracy assessment, and Definiens 5.0 software and ERDAS IMAGINE 8.6 software are used to do image segmentation and classification respectively.

3 Methodology

Land consolidation implementation monitoring is based on two remote sensing images before and after land consolidation, incorporating the correlation analysis concept using bi-temporal imagery into object-based image processing (i. e. mage segmentation). The correlation image analysis is based on the fact that pairs of brightness values from the same geographic area (e. g. an image object) between bi-temporal image datasets tend to be highly correlated where there is no land consolidation occurred, and uncorrelated where zone type land consolidation engineering have been consolidated [12-13]. This monitoring process involve two vital techniques: image segmentation and correlation analysis using object correlation images(OCIs). And there are 4 steps in sum in the whole process: (1) image preprocessing, (2) multi-resolution image segmentation, (3) correction image analysis, (4) classification, the flowchart of which is as Fig. 2.

Image segmentation is used to get zone type land consolidation engineering objects, which are the basics of implementation monitoring analysis. Based on the change detection model based on neighbothood correction image analysis by Im J. *et al*. [21-22], the methodology was generalized to solve implementation monitoring of land consolidation engineering using object oriented method. The implementation monitoring assumes that the spatial resolution of remote sensing images is high. This general assumption should be respected to ensure the efficiency of this method.

3.1 Image segmentation

The foundation of object oriented method is image segmentation, which consists in partitioning an image into objects which group pixels that are spatially,spectrally and temporally similar. It subdivides the image into meaningful homogeneous regions based not only on spectral properties but also on shape, texture, size and other topological features, and organizes them hierarchically as image world objects, proper in shape. Including two SPOT images

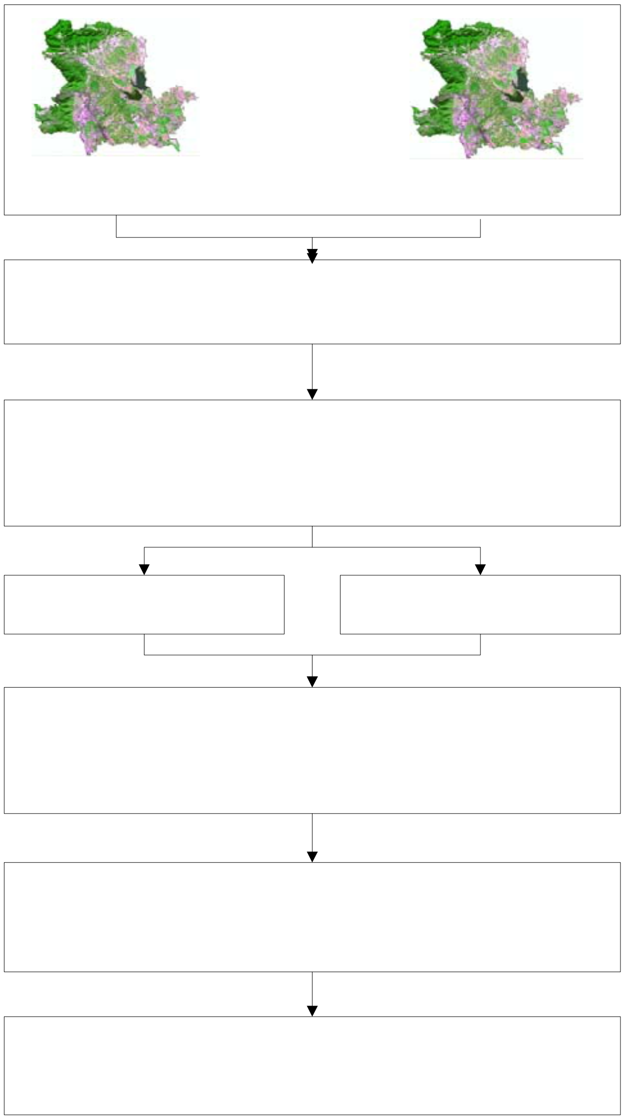

Fig. 2 Flow diagram of land consolidation implementation motering model

over the same location at two different dates,the multidate image is segmented into multidate objects[23]. In this study, image objects are created using the image segmentation tool in Definiens 5.0 (whose old version name is eCognition) software. The segmentation process in Definiens 5.0 is a bottom-up region-merging approach starting with one pixel objects, where the smallest objects contain single pixels[23]. In numerous subsequent steps,smaller image objects are merged into bigger ones.Throughout this pairwise clustering process,the underlying optimization procedure minimizes the weighted heterogeneity of resulting image objects, where n is the size of a segment and an arbitrary definition of heterogeneity.In each step, that pair of adjacent image objects is merged which stands for the smallest growth of the defined heterogeneity.If the smallest growth exceeds the threshold defined by the scale parameter,the process stops. In the sense of application, multiresolution segmentation is a local optimisation procedure. The spectral feature space is separated into subdivisions, and pixels of the same subdivision are merged when locally adjacent in the image data. The main idea of region-merging technique is to collect the pixels whose attribute values are alike to a region. A seed pixel is found to be a jumping-off point of region-merging at first, then neighbouring pixels those attribute value are same or alike would be consolidated into the region that the seeding pixel lies in. These new pixels will be acted as new seeding to continue foregoing operation until no pixel which is fit to be included in [24]. The segmentation is based on an optimization function which involves three parameters, namely the scale parameters, the spectral, and the compactness. The spectral parameter w_{color}, trading spectral homogeneity vs. object shape, is included in order to obtain spectrally homogenous objects while irregular or branched objects are avoided. The compactness parameter w_{cmpct}, trading compactness vs. smoothness, adjusts the object shape between compact objects and smooth boundaries. The relationship of spectral parameter and shape parameter is as followed:

$$f = w \times h_{color} + (1-w) \times h_{shape} \tag{1}$$

Spectral homogeneity value h_{color} is related to not only pixel numbers which form image objects, but also standard deviation of all bands, which is expressed as:

$$h_{color} = \sum_c w_c \left(n_{Merge} \times \sigma_c^{Merge} - \left(n_{Obj1} \times \sigma_c^{Obj1} + n_{Obj2} \times \sigma_c^{Obj2} \right) \right) \tag{2}$$

Shape homogeneity value h_{shape} is composed of compactness h_{sc} and smoothness h_{smooth}:

$$h_{shape} = w_{cmpct} \times h_{cmpct} + \left(1 - w_{cmpct}\right) \times h_{smooth} \tag{3}$$

Compactness and smoothness are decided by pixel numbers n composing image objects, perimeter l of pologons, minimal boder length of equal pologon.

$$h_{smooth} = n_{Merge} \times \frac{l_{Merge}}{b_{Merge}} - \left(n_{Obj1} \times \frac{l_{Obj1}}{b_{Obj1}} + n_{Obj2} \times \frac{l_{Obj2}}{b_{Obj2}} \right) \tag{4}$$

$$h_{cmpct} = n_{Merge} \times \frac{l_{Merge}}{\sqrt{n_{Merge}}} - \left(n_{Obj1} \times \frac{l_{Obj1}}{b_{Obj1}} + n_{Obj2} \times \frac{l_{Obj2}}{b_{Obj2}} \right) \tag{5}$$

Finally, the scale parameter h_{sc}, controlling the object size, is selected in order that the minimum object size matches the Minimum Mapping Unit (MMU). Depending on this scale parameter, different segmentation levels can be produced, each characterized by their own mean object size.

SPOT 5 images are segmented in this study. There are 12 bands are used in image segmentation: 8 multispectral bands, 2 panchromatic band and 2 textural band of panchromatic image. Large scale objects and small scale objects of imagery lie in the Region of Interesting simultaneity, which make a multi-scale hierarchical network of objects come into being. The image was subdivided into separated regions at 3 levels with different parameters in sum, detailed in table 1. For segmentation, choosing the right bands for a level had quite some impact in forming objects. Original SPOT 5 images and their segmented results are listed in Figure 3.

The scale parameter was the most determining factor in the size of the objects. Colour and shape were weighted according to the type of land us to be classified. The shape settings of the shape parameter did not gave any clear indication for use with a certain land use type; therefore it was set to the default value. In the process of parameter selection, we find that spectral information is the vital data included in remote sensing images and too high shape factor weight will result in the loss of spectral homogeneity. So there are two principles to be taken: the weight of colour factor should be big as it can be as possible; to those image objects, whose compactness are high, we should use necessary shape factors as we can as possible.

(a)

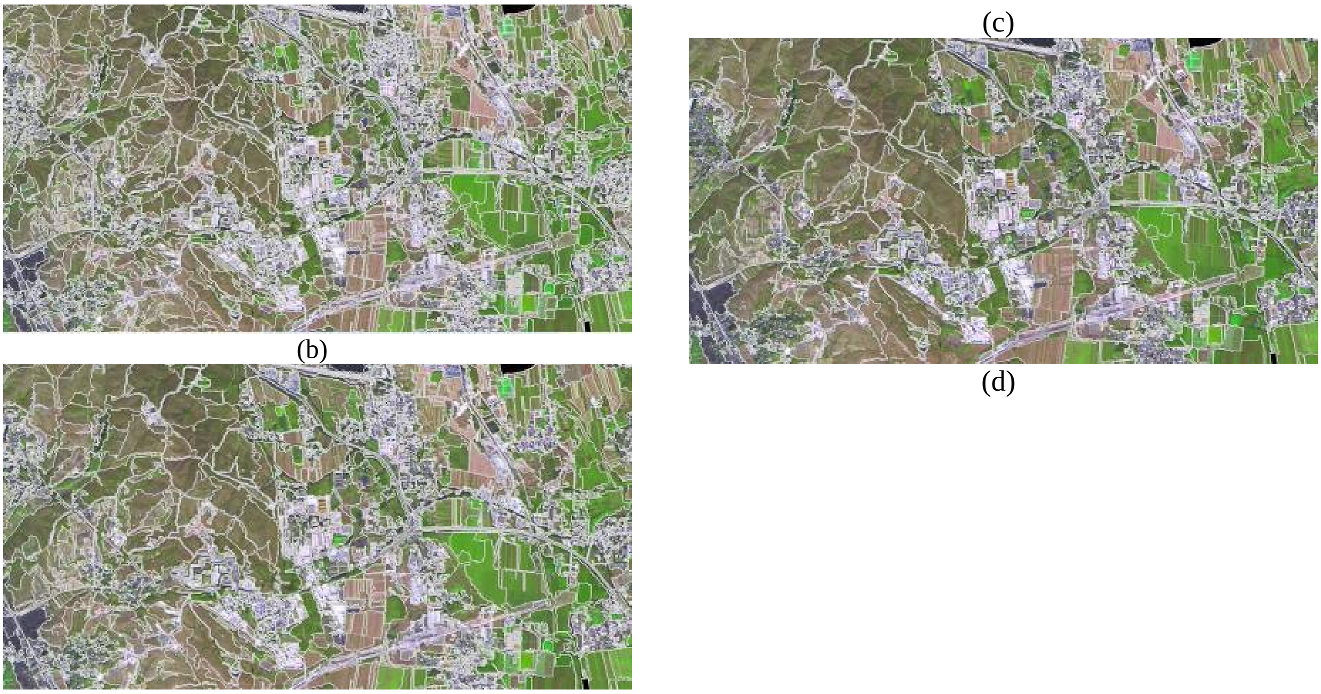

Fig. 3 Original SPOT 5 image and segmented results on 3 levels: (a) is the multi-bands of original SPOT 5 image; (b) is segmented result on level 1; (c) is segmented result on level 2; (d) is segmented result on level 3.

Tab.1 Segmentation parameters

Segmentation level	Segmentation parameters				
	Scale parameter	Homogeneity criterion			
		Colour parameter	Shape parameter	Shape settings	
				smoothness	compactness
Level 1	50	0.7	0.3	0.8	0.2
Level 2	85	0.8	0.2	0.7	0.3
Level 3	100	0.8	0.2	0.7	0.3

3.2 Correlation image analysis

Correlation analysis was used to monitor land consolidation engineering implementation based on the objects derived from image segmentation. Three variables, such as correlation, slope, and intercept, from the correlation analysis were calculated referencing from Im J. & Jensen J. R.[21]. It will be demonstrated that the correlation between two multispectral images which are befor and after land consolodation, providing valuable information regarding the location and characteristics of land consolidation engineering implementation. The correlation information derived from a specific window size (e.g. 3×3) contains valuable change information associated with a central pixel and its contextual neighbors. Slope and intercept images provide change-related information that can be used as ancillary data to facilitate change detection with correlation.The degree of correlation, slope, and intercept can then be used to produce detailed "from–to" change information when combined with object-oriented classification techniques[21].

Compared with the research of Im J. *et al.*, there is an improvement in this study: the textural information is used in object oriented implementation monitoring process. The change magnitude and direction of brightness and texture values are used in correlation image analysis. Such three object correlation images(OCIs) are created based on brightness and texture values by band in an object or a specified neighbourhood between two multispectral remote sensing datasets. The algorithms of correlation between brightness values of two dates of imagery in the local neighborhoods is calculated as:

$$r = \frac{\mathrm{cov}_{12}}{s_1 s_2} \tag{6}$$

where

$$\mathrm{cov}_{12} \frac{\sum_{i=1}^{n}\left(BV_{i1}-\mu_1\right)\left(BV_{i2}-\mu_2\right)}{n-1} \tag{7}$$

r: is Pearson's product–moment correlation coefficient;

cov_{12} : is the covariance between brightness values found in all bands of the two date data sets in the neighborhood;

s1, s2: is the standard deviations of the brightness values found in all bands of each data set in the neighborhood,respectively;

BV_{i1} : is the ith brightness value of the pixels found in all bands of image 1 in the neighborhood;

BV_{i2} : is the ith brightness value of the pixels found in all bands of image 2 in the neighborhood;

n : the total number of the pixels found in all bands of each data set in the neighborhood;

μ_1 , μ_2 : are the means of brightness values found in all bands of the two date (1 and 2) images in the neighborhood,respectively.

Slope and y-intercept are calculated from the least squares estimates as followed:

$$slope = \frac{\mathrm{cov}_{12}}{s_1^2} \tag{8}$$

$$\text{intercept}= \frac{\sum_{i=1}^{n} \mathrm{BV}_{i2} - slope\sum_{i=1}^{n} BV_{i1}}{n} \tag{9}$$

GLCM is the most popular textural feature to describe spatial properties[25-26]. There are 4 GLCM texture features are calculated in this research: algorithms of them are defined as formula (10)-(13). And the identification of these texture measures considered as optimal for land cover classification is based on the prototype performance approach and its application [22].

Homogeneity: $$HOM = \sum_i \sum_j \frac{P_{d,r}{}^{(i,j)}}{1+(i-j)^2} \tag{10}$$

Contrast: $$CON = \sum_{\mathrm{i}} \sum_{\mathrm{j}} (\mathrm{i}-\mathrm{j})^2 P_{d,r}{}^{(i,j)} \tag{11}$$

Angular second moment:

$$ASM = \sum_{\mathrm{i}} \sum_{\mathrm{j}} \left[P_{d,r}{}^{(i,j)} \right]^2 \tag{12}$$

Entropy: $$ENT = \sum_{\mathrm{i}} \sum_{\mathrm{j}} P_{d,r}{}^{(i,j)} \left[-\ln \left[P_{d,r}{}^{(i,j)} \right] \right] \tag{13}$$

Where i is the row number and j is the column number; $P(i,j)$ is the normalized value in the cell (i,j) ; d is the distance separating pairs of pixels; r is the given direction.

3.3 Implementation/Non- Implementation classification

An automated object-based classification was developed to distinguish implementation status of land consolidation engineering: sloping wasteland to cultivated land, abandoned beach to cultivated land, segmental land to large scale land, using correlation image analysis method. There are 4 classes, namely non-changed areas, sloping wasteland to cultivated land, abandoned beach to cultivated land, segmental land to large scale land, are discriminated.

The identification of implementation and non-implementation is based on two steps, namely (1) correlation image analysis based on segmented image objects and (2) distinguishing implementation / non-implementation between all image objects setting a given threshold. If the difference of two image objects in a same area resulting from these two phase remote sensing images exceed the threshold, this object is distinguished as implementation object, whereas non-implementation object.

3.4 Implementation change detection

There are two kinds of classifiers are used in this land consolidation engineering implementation monitoring procedure: Maximum Likelihood Classifier(MLC) and Nearest Neighbour Classifier(NNC). Maximum Likelihood Classifier is most widely used supervised classifier for remote sensing image processing, available in most remote sensing software. The principle of this classifier is: the probability of an object belonging to each of a predefined set of classes is calculated, and the object is then assigned to the class for which the probability is the highest. The Nearest-Neighbour Classifier is a default object-based classification method in Definiens 5.0 software. The standard Nearest Neighbour algorithm in eCognition computes the Euclidean distance from the object, and the final assignment of an object will go to the class that has the sample nearest to the nearest training object in the given feature space and assigns it to the class of the training object. There are 12 bands of bi-temporal SPOT 5 images: 8 multispectral bands, 2 panchromatic band and 2 textural band of panchromatic image. The supervised classification method is used to monitoring changed zone features in land consolidation engineering in this study, and there are three kinds of land consolidation types are sampled: sloping wasteland to cultivated land (24 pixels),abandoned beach to cultivated land (18 pixels), segmental land to large scale land (36 pixels).

In view of only the natural information can be expressed using remote sensing image, there are some pseudo-changed areas of land consolidation are detected: the areas where cultivated crops change(such as maize to soybean), the areas where crop growth are different. These areas should be detected and amended in post classification processing.

3.5 Accuracy assessment

The classification result based on this methodology was assessed using reference data set including objects selected by stratified random sampling. These objects are compared with land use type resulting from field work. Testing samples are selected randomly to assess the implementation monitoring accuracy of land consolidation engineering using SPOT 5 image, which have been validated in field work. The following testing samples are collected in this experiment: sloping wasteland to cultivated land(18 pixels),abandoned beach to cultivated land(12 pixels), segmental land to large scale land(22 pixels), the position and number of which are different from the training samples. Four performance indices were derived from the confusion matrix: overall accuracy, overall kappa and, for the change class, the omission and commission errors. The pixel-based classification result and object oriented classification method are separately assessed.

4 Results and discussion

The generated object correlation images(OCIs) are used in object oriented implementation monitoring meyhod of zone features in land consolidation engineering using SPOT 5 imagery. Table 2 and table 3 are the accuracy assessment results of traditional pixel-based classification method and object oriented classification method to monitor land consolidation implementation. The classification accuracy of pixel-based method (total accuracy is 80.72%, Kappa coefficient is 0.7099) is higher than object oriented classification method(total accuracy is 86.30%, Kappa coefficient is 0.7931). Among the three change types, the accuracy assessment of segmental land to large scale land is the highest, whose producer's accuracy is up to 90.08%. Figure 4 documents the object oriented implementation monitoring outputs of zone type land consolidation engineering:

Tab.2 Accuracy assessment result of pixel-based classification method

	sloping wasteland to cultivated land	abandoned beach to cultivated land	segmental land to large scale land	Total	User's accuracy (%)
sloping wasteland to cultivated land	163	26	23	212	76.89
abandoned beach to cultivated land	59	141	21	221	63.8
segmental land to large scale land	0	0	236	236	100
Total	222	167	280		
Producer's accuracy (%)	73.42	84.43	84.29		

Total accuracy: 80.72% , Kappa coefficient: 0.7099.

Tab.3 Accuracy assessment result of object oriented classification method

	sloping wasteland to cultivated land	abandoned beach to cultivated land	segmental land to large scale land	Total	User's accuracy (%)
sloping wasteland to cultivated land	153	26	23	202	75.74
abandoned beach to cultivated land	35	159	3	197	80.71
segmental land to large scale land	0	0	236	236	100
Total	188	185	262		
Producer's accuracy (%)	81.38	85.95	90.08		

Total accuracy: 86.30%, Kappa coefficient: 0.7931.

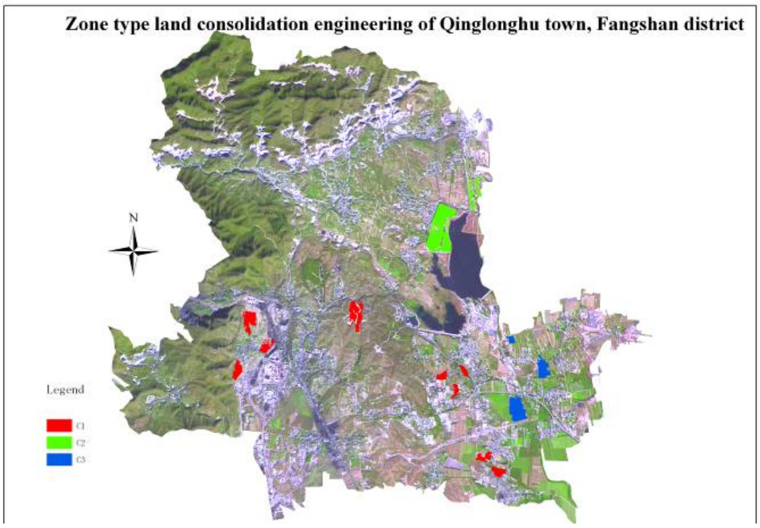

Fig. 4 Land consolidation engineering implementation monitoring result

Notes: C1 is sloping wasteland to cultivated land, C2 is from abandoned beach to cultivated land, C3 is from segmental land to large scale land

5 Discussions

This study proposes an automated method to monitor implementation status of land consolidation engineering in Qinglonghu County, Fangshan District, Beijing. The implementation monitoring based on image objects has the advantage of reducing the spectral noise due to complex land use types, but also reducing pseudo implementation areas. Compared with post-classification comparison method, which need classify two remote sensing images before and after land consolidation at first step, this correlation analysis method detects implementation areas directly. Because this method is based on the original satellite image as for implementation monitoring, the resulting land consolidation implementation map should be more accurate, which is impervious to classification error.

One difficulty coming from the diversity of land use types and their different spectral signatures is solved by stratifying the classification based on the large objects. There is one point should be noted that a limitation of object-based methods is that small deforested areas are not taken into account.Indeed,the scale parameter required for the segmentation defines the minimum object size. This is solved by multi-resolution segmentation in this study.

This land consolidation implementation motoring method can be considered as a change detection method, which is operational given its efficiency to monitor land consolidation implementation status. Indeed, its good overall performance over land consolidation areas prove its ability to identify small clearing spread over the landscape as well as large parcels. Moreover, whereas high cost, taking time, hard sledding of this implementation motoring using traditional investigation method of manpower in the past, the current large variety of easy-to-access satellite imageries renders fine spatial resolution images very promising to apply this automated land consolidation implementation monitoring technique in an operational framework.

6 Conclusion

Zone features implementation monitoring in land consolidation is successfully delineated from high resolution SPOT 5 satellite images using correlation analysis method in this study. Compared with traditional pixel-based implementation monitoring method, object oriented implementation monitoring method of zone type land consolidation engineering provide many improvements and several advantages. Object correlation images (OCIs) are used in to detect zone type land consolidation engineering, which are expressed changed objects. This method apply in the study revealed 2 advantages. Firstly, there are reduced *pepper and salt effect* in object oriented implementation monitoring method, because the basic studied areas are objects , not single pixels. Secondly, the accuracy of zone type land consolidation engineering of segmental land to large scale land is improved. Furthermore, compared classification result using traditional pixel-based classification method, the total accuracy increases form 80.72% to 86.30% using this method. All these results indicate that object oriented implementation monitoring method is proper to zone fetures in land consolidation engineering, which can be generalized to other high resolution image such as QuickBird image, IKONOS image.

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