Large-scale Forest Resource Dynamic Monitoring Using Worldview-2 data—A Case Study in Pingtan Island, Fujian Province, China

HUANG Wei, WANG Xiaoqin, CHEN Yunzhi, ZHOU Xiaocheng & XIAO Nengwen
Key Laboratory of Spatial Data Mining & Information Sharing of Ministry of Education, Fuzhou University, Fuzhou, China

E-mail: Wangxq@fzu.edu.cn

Abstract. Due to its capacity to describe detailed information., high spatial resolution remote sensing technology has been used increasely in forest resource dynamic monitoring, especially at large scale. Based on 0.5m resolution Worldview-2 data and 1:10000 forest stand-wise vector data, monitoring on forest resource dynamic during 2010-2011 in Pingtan Island is carried out. Object-oriented classification method was adopted. Firstly, multi-resolution segmentation was done on Worldview-2 image, which produced two levels of objects. The boundary of objects at the first level corresponded to boundary of individual polygon in the forest stand-wise data coverage. The more homogeneous objects at the second level were smaller and within the objects at the first level. Then, hierarchical supervised classification was used to classify the second-level objects. The objects were assigned to seven different thematic layers according to the attribute of land use types of forest stand-wise data, then object samples were selected for supervised classification to identify the change of objects in each layer. Changed objects larger than $0.0667hm^2$ were preserved and used for dynamics analysis. The classification accuracy was assessed by field survey and one-by-one visual interpretation. The result indicated that the overall accuracy was 90.85%. Forest in Pingtan Island had changed greatly during 2010-2011, area of forest increase and decrease is 2314.7817 hm^2 and 1089.6508 hm^2 respectively.

1. Introduction

The traditional forest resource monitoring system based on remote sensing normally adopts the remote sensing image of low and medium resolution, such as Landsat 5/7, TM/ETM+, MODIS and so on. However, with the rapid social economy development and the fast popularization of high spatial resolution remote sensing image, the medium and low resolution remote sensing image alone can no longer meet the production and practical requirements in forest resources monitoring. High spatial resolution remote sensing optical and radar image, such as SPOT5, QuickBird and Worldview, are more frequently used in object-oriented classification technique, meanwhile, the combination of remote sensing image and large scale vector data is one of the development trend. Hu Rongming [1]and Chuan Zhang[2], based on SPOT5 remote sensing data, implement comparison researches between the classification technique based on pixel and object-oriented classification technique. The research result shows that there is certain limitation when adopting the classification technique based on pixel to process high spatial resolution remote image while the object-oriented classification

performs better in both classification efficiency and precision compared with the traditional classification technique based on pixel. The object-oriented classification can effectively make used of image's spectral information, geometric structure, spatial information and contextual information. In addition, it could provide the advantage of making use of multi-source data for mining information from multi-resolution segmentation[1,3]. It has been adopted in forest resource large scale monitoring, such as R V Platt, T.Schoennagel[4] and Chen[5]adopt the object-oriented classification technique to classify remote sensing image and gain combustible classification change information within the researched forest, which realizes the combustibles' dynamic control in experimental forest through remote sensing technology.

Currently, there are some still issues existed in object-oriented classification technique, such as the best scale choice, classification feature choice and the integration between split objects and geographic data. In the aspect of best segmentation scale, Shukui Bo and Xinchao Han[6], based on that no common best segmentation scale has been reached, put forward a method to determine the best segmentation scale. Chen Chunlei[7], based on the evaluation of remote sensing image's best segmentation scale for object-oriented classification technique, puts forward the evaluation model and adopts the QuickBird remote sensing image's experimental data for approving. In the aspect of classification type, Zhang Yinna[8] has improved the Relief F algorithm and puts forward the improved evaluation algorithm, the Relief FO algorithm. Yu Xiaoming[9], based on threshold separating method, puts forward the improved SeaTH algorithm, the ISEaTH algorithm from the evaluation features of between-class distance without consideration of interdependency between between-class distance and features. Based on object-oriented non-supervised classification, Yu Xianchuan[10] puts forward automatic classification method and the experimental result shows that it could effectively make uses of more image feature information for clustering and reduce the number of cluster objects. Therefore, it could significantly improve the precision and efficiency of automatic classification. In order to improve object-oriented classification precision based on SPOT5 under large scale, Li Chungan[11] puts forward the New Voting-fuzz method that comprehensively integrates multi-classifications from traditional voting method and fuzz method.

This paper adopts the Pingtan Island in Pingtan County, Fuzhou City as research area and adopts the 0.5 m high spatial resolution remote sensing image to research classification technique for 1:10000 stand-wise data vector data updating, so as to realize the rapid and accurate extraction of dynamic forest resources change information and to provide reference for Fujian provincial large scale forest resources' dynamic remote sensing monitoring.

2. Study area and data

The research area was the Pingtan Island in Pingtan County, Fuzhou City. Pingtan County locates in the eastern coastal area in Fujian Province, near Taiwan Strait, around east longitude 119°32'~ 120°10' and north latitude 25°15'~ 25°45'. The landform of Pingtan is mainly marine plain with islands while the geographic type includes hills, terrace, marine plain, lakes, beaches and sea coast; the agro-type includes laterite, aeolian sandy soil and saline soil. The type of forest is mainly shelter forest. Therefore, no matter judged from forest resource distribution, climate or landform, the researched area is representative [12]. Since Pingtan is the China mainland area that is nearest to Taiwan Island, it has unique advantage in communication and cooperation across Taiwan Strait. In July 2009, in accordance with requirements in Economic Zone Development Plan for Western Coast of Taiwan Strait issued by State Council, Fujian Provincial Party Committee and Government made the decision of establishing Pingtan Comprehensive Experimental Zone. Since then, Pingtan Began the large scale biology building and economy building. After three years' building and development, Pingtan Island's status of land use and forest resources have been changed significantly, and an urgent forest resources monitoring investigation is need to check out current forest resources condition and examine the achievement of three years' biology building.

The research data mainly includes forest vector stand-wise data and Worldview-2 remote sensing data of this area. The forest stand-wise data was produced in 2010 with the scale of 1:10000; the

remote image data received date was January 2012. The panchromatic image resolution is 0.5m; high resolution image include 8 spectrums, namely red, green, blue, near-infrared, sea coast, yellow, infrared and near-infrared 2, with a resolution of 2.0m. In addition, this paper also collects Pingtan County's 1:10000 forest fundamental map, 1:10000 geographic map and other social and economic statistic data.

3. Method

Dynamic monitor process include four procedures, namely data pre-processing, remote sensing image's multi-scale segmentation , different layer supervised classifying and field survey and internal document sortation after classification.

3.1. Data pre-processing

Pingtan Island Worldview-2 image adopts 1:10000 geographically approved remote sensing data as data source and uses 1:10000 DEM for ortho-rectification. The multispectral data and high resolution data adopts PanSharp method to integrate and inlay after integration. Finally, transform remote sensing image into coordinate system in according to acquired stand-wise data coordinate system to combine remote sensing image and stand-wise data precisely for the processing in next procedure.

3.2. Multi-scale segmentation

Since the multi-scale segmentation has taken the multi-layer of land appearance into consideration and has overcome the fixed size of data source, it could effectively make use of different land type information to adopt the most suitable segmentation scale for specific land and forest types. Therefore, this segmentation adopts multi-scale segmentation method.

Firstly, combine stand-wise data with remote sensing image and adopt chessboard segmentation algorithm to split the image primarily. The object boarder that produced by segmentation is stand-wise board, and each polygon represents a stand-wise object. By adopting this method for segmentation, the boarder information of original stand-wise can be fully reserved, which is useful for the stand-wise data update after classification. In case that the original image is directly segmented, the boarder of object will be different from the boarder of original stand-wise, resulting in large sum of updating jobs for stand-wise after classification.
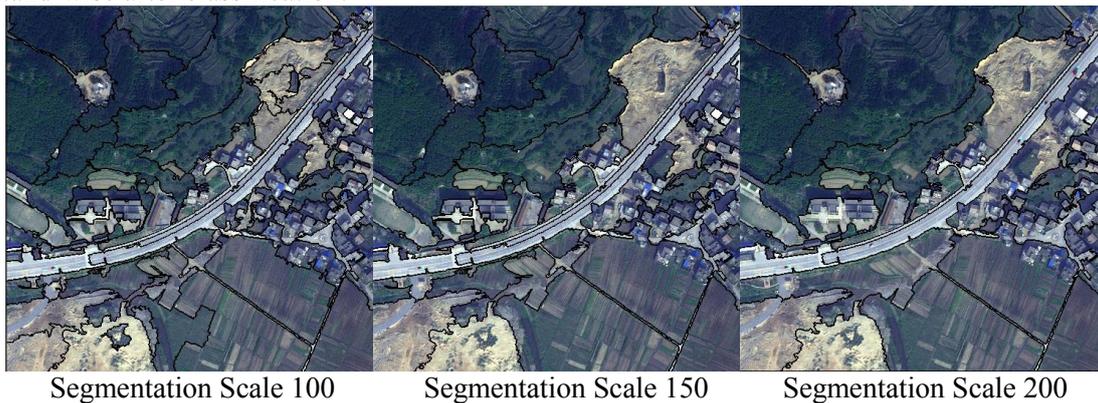
Segmentation Scale 100   Segmentation Scale 150   Segmentation Scale 200
Figure 1 The result in different segmentation scale

Secondly, several different segmentation scale was chose to determine the best segmentation scale. Shown as figure 1, using different scale to do segmentation can bring different segmentation results. Through comparative analysis of artificial visual interpretation, the segmentation result of segmentation scale 150 was the best of all.

3.3. Different layer supervised classification

The different layer monitoring classification can effectively and simply make use of inner land type information inside different image layer. When choosing practice sample area, based on the

phenomenon of same object with different spectrum, the type classification method can be adopted to improve between-class separation to improve classification efficiency and accuracy[5,13,14]. Therefore, this paper adopts different layer supervised classification method.

After determining forest's layer system, the layer classification can be directly made in eCognition. Choose different wave bands or wave band combination based on 8 different wave bands, and choose the between-class's significant feature or certain number of training sample for monitor classification and gradually acquire objects of different land types; finally acquire the stand-wise object that changes in all thematic layers.

Below, we choose no wood land (DL>150 and DL<200) as example to introduce the extraction of changed area in no woodland land thematic image. No woodland mainly includes burnt remains, wood cutting remains, desert land and hills suitable for forest and sand land suitable for forest. For those stand-wise objects that changes from no wood land to wood land, normalized difference vegetation index (NDVI) is adopted for determining and extracting through choosing certain amount of training samples and discover that threshold value of 0.25 is suitable, and the wood land stand-wise objects (DL>150 and DL<200 and NDVI>0.25) that changed from original no wood region can be extracted. For those stand-wise object that changed from wood land to no wood land, mainly water object, farming land and building land, in the false color image, water object will be indicated by dark color. The farming land without crop or building land will be indicated by grey or white color. Therefore, they are significantly different from other objects and are suitable for serving as training sample. This paper adopts the nearest neighbourhood classification to monitor the classifying and extracting these three kinds of objects. Since the open forest land, planted land, nursery land and farming land with crops are not distinguishing with each other, the sample is directly adopted for primary monitor classification. As these four kinds of land types are of small area, they can be manually modified in the post production.

3.4. Post Processing
Due to the existence of same object with different spectrums and same object with different images, the classification result needs manual modification. In eCognition, the manual classification for images before and after classification, manual correction of classification result, together with object-oriented classification's correction on the objects produced by classification and traditional image element classification are able to effectively improve correction efficiency and accuracy.

4. Result
After putting changed classification results for regrouping in accordance with changing rule, the forest resource change map can be got and exported as Fig.2(a). After putting thematic image together to form a new group of same classification and regroup the changed areas according to changed types, the present forest resource distribution situation map can be got and exported as Fig.2(b).
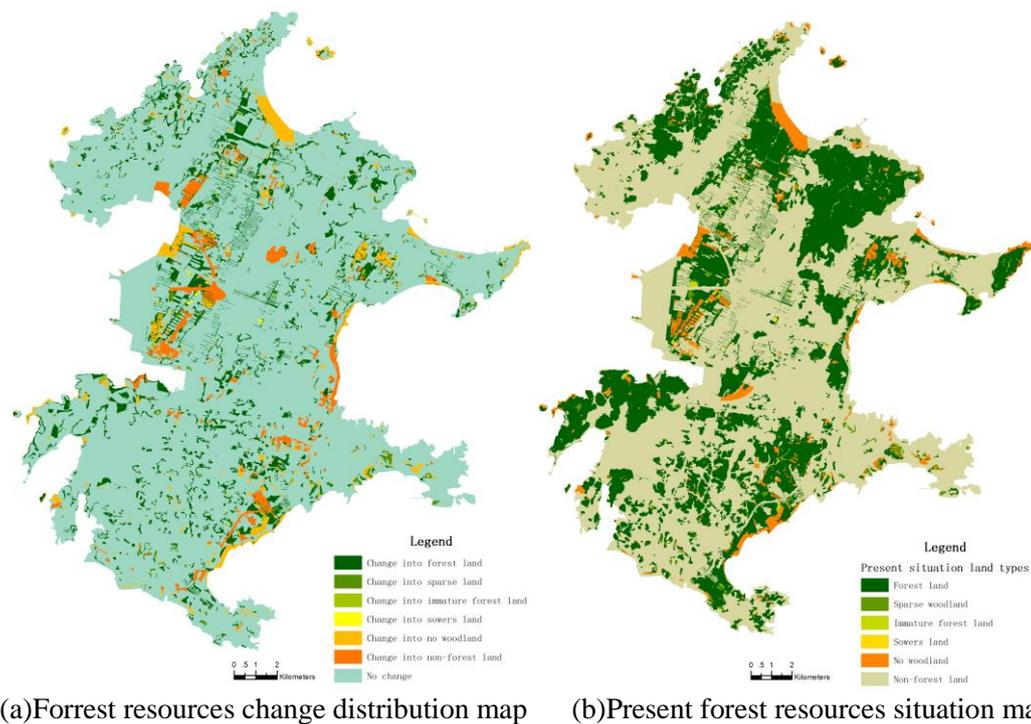
(a)Forrest resources change distribution map   (b)Present forest resources situation map
Fig.2 The thematic maps of forest resources changes and present situation in Pingtan Island

5. Discussion and Conclusion

The statistics shows that the area that forest resource in Pingtan Island is changing towards a positive direction (the forest coverage rate is increasing) and that is changing towards passive direction (the forest coverage rate is decreasing) have reached 2205.322 hectare and 946.378 hectare respectively, while the original blank area is 1095.769 hectare. The area that has positive changes is much larger than that has passive change, showing that, three years after the establishment of Pingtan Comprehensive Experimental Zone, the making forest activity in Pingtan Island has achieved the positive result. In addition to overcoming the forest reduction influence caused by large scale economy building, Pingtan Island has significantly improved forest coverage to provide effective biologic shelter for the successful building of Pingtan Comprehensive Zone.

The accuracy assessment of this classification is mainly based on eyesight determination and outdoor investigation. The outdoor investigation was performed in June 2012 to focus on the stand-wise object that has passive change. 416 out of 4177 changed objects with unclear image features were selected for outdoor survey approval. In addition, the interpretation marks were established for eyesight checking. The examination result is indicated as Table 1.

Table1 The accuracy assessment

Classification	Total QTY	Correct Interpretation	Wrong Interpretation	Accuracy Rate
Uncertain Changed polygon	416	117	299	0.2813
Certain Changed polygon	3761	3483	278	0.9261
Total Changed polygon	4177	3600	577	0.8619
Unchanged polygon	2688	2637	51	0.981
All polygon	6865	6237	628	0.9085

Judged from above table, the manual identification accuracy on uncertain polygon is low, since only 117 out of 416 polygon are correctly identified and the accuracy rate is only 27.125%. However, judged from total changed polygon, 3600 out of 4177 polygon are correctly identified and the

identification accuracy rate is 86.186%. For all 6865 polygon, the identification accuracy rate is 90.852%. The main reason of identification mistakes is that the survey only adopts the information on remote sensing image rather than referencing to the stand-wise changing records in Forestry Department; therefore, it causes some poor accuracy in pre-identification of changes in open forest land, planted land and no wood land. The method for these object identifications need improvement.

The 0.5m spatial resolution Worldview-2 remote sensing image and object-oriented classification based on different layers and types are adopted to effectively monitor the forest resources changes in Pingtan Island in recent two years. In the object-oriented classification, the original forest stand-wise image layer is fully utilized to limit image object within all forest stand-wise boarder, which is useful in realizing stand-wise image layer update. The application of this technique, based on the fully use of image object's spectral information, significantly improves changed monitor's efficiency, reduces manual jobs and improves classification accuracy. Meanwhile, due to the existence of same object with different spectrums and same object with different images, the high definition remote sensing image alone has poor accuracy in identifying planted land, open forest land, and no wood land. Therefore, the method need further improvements.

6. References

[1]   Rongming Hu, Wei Man, Chengbin Yang, Junbin He 2012 Taking SPOT5 Remote Sensing Data for Example to Compare Pixel-based and Object-oriented Classification. *Remote Sensing Technology and Application*, **3** 27.

[2]   Chuan Zhang, Yingjun Zhao, Donghui Zhang, Ningbo Zhao 2011 Application and Evaluation of Object-Oriented Technology in High-Resolution Remote Sensing Image Classification. *International Conference on Control, Automation and System Engineering*.

[3]   Min Zhang, Yunxuan Zhou, Jin Huang 2010 Research of Object-orinted Classification Method for High-spatial Resolution Remote Sensing Image Used in Land Use/Cover. *International Conference on Multimedia Technology*.

[4]   R V Platt, T Schoennagel 2009 An object-oriented approach to assessing changes in tree cover in the Colorado Front Range 1938-1999, *Forest Ecology and Management*, **258** 1342-1349.

[5]   Yunzhi Chen, Chongcheng Chen, Xiaoqin Wang2008. Forest Fuel Types Classification and Change Detetion by Remote Sensing in Zhangping City. *Geo-Information Science*, **10** 792-797.

[6]   Shukui Bo, Xinchao Han 2010 Parameter selection for segmentation in object-oriented classification of remotely sensed imagery. *International Conference on Intelligent Computation Technology and Automation*, 876-879.

[7]   Chunlei Chen, Gang Wu 2011 Evalution of Optimal Segmentation Scale with Object-oriented Method in Romote Sensing. *Remote Sensing Technology and Application*, **26** 96-102.

[8]   Yingna Zhang, Chao Zhang, Dongling Zhao, Jianyu Yang 2010 Object-Oriented Feature Selection Algorithms with Relief FO and Haiming Genetic Algorithm. *Geomatics and Information Science of Wuhan University*,**35** 1444-1448.

[9]   Xiaomin Yu, Feibing Zhan, Mingsheng Liao, Jinxing Hu 2012. Object-oriented Feature Selection Algorithms Based on Improved SeaTH Algorithms. *Geomatics and Information Science of Wuhan University*, **37** 921-924.

[10]   Xianchuan Yu, Weijie An, Hui He 2012 A method of auto classification based on object oriented unsupervised classification. *Progress In Geophysics*, **27** 744-749.

[11]   Chungan Li, Guofan Shao 2010 Object-Oriented Classification of Forest Cover Using SPOT5 Imagery. *Sciential Silvae Sinicae*, **48** 130-139.

[12]   Xiao Sheng 2006 Study on Protective Froest Resources in Pingtan Island using SPOT and Landsat ETM+ Image . *Journal of Fuzhou University(Natural Science)*, **34** 669-673.

[13]   Chen Yunzhi, Chen Chongcheng, Wang Xiaoqin, Ling Feilong 2004 Application of Multi-Source Data to Forest Dynamic Monitoring . *Resources Science* ,**26** 146-152.

[14]   Xue Xinyu, Liu Hongyu 2012 Study on the Classification Approaches of Yancheng Coastal Wetlands based on ALOS Image . *Remote Sensing Technology and Application*, **27** 248-255