A Classification Method of Land Cover Based on Support Vector Machines

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Abstract. In this paper, we develop a classification method of land cover based on support vector machines. As a case study, we choose five Landsat images to retrieve land cover maps in Shenzhen, China from 1979 to 2005. The classification method is based on support vector machines with assistance from visual interpretation. And then we take use of the complex network approach to analyze the character of land use-cover change from an overall perspective. The result shows that the main changes of land use-cover are different over time. The medium of bare land during the urban construction can hardly be witnessed, even though the time intervals are shorter than the two periods before. It reveals the transformation from vegetation to urban becomes faster. The transformation from vegetation to bare land is hard to be witnessed in the late stage. As bare land is the medium for transforming vegetation to urban land in Shenzhen during the past years from 1979 to 2005.

Keywords: Land cover change · Support vector machines · Remote sensing

1 Introduction

It plays an important role to study the rapid and effective land cover classification method for timely updating of land use information. The land cover is the result from the mutual effect between human activities and nature processes. Land cover change can directly bring climate change, affect biological species diversity and the ecological system [1–3]. The research on the land use-cover change (LUCC) can facilitate to understand the situation and mechanism of land environment. It is very important to the rational use of land resource and reconciliation of socio-economic development [4, 5]. Moreover, the rapid development of technologies on remote sensing provide big data and analysis tools for LUCC research. There have been plenty of studies in this field, which focus on LUCC monitor, mechanism, modeling, and so on [6–10].

Shenzhen belongs to Guangdong province, located in the east coast of Pearl River Delta. After the rapid development in recent decades, its economic aggregate has

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increased from 196 million in 1979 to 1151 billion in 2011. The development of remote sensing satellites in recent decades offers a good opportunity to capture this process. Studying the spatio-temporal character of Shenzhen LUCC has important implications to give support to government for making the land policy.

There are already some studies on Shenzhen LUCC research, including the LUCC character analysis, forcing driver analysis, dynamic modeling and prediction [11–14]. Some work focused on the modeling method, such as the model improvement and precision validation. Some only used two images while the time series of LUCC cannot be captured.

In this paper, we develop a classification method of land cover based on support vector machines. As a case study, we retrieve Shenzhen land cover maps in five timing points from 1979 to 2005, and then take use of the complex network approach to analyze the character of land use-cover change from an overall perspective. At last, the correlation between urban expansion and socio-economic factors are discussed.

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2 Data and Method

2.1 Data Introduction

The research region covers most Shenzhen city and some surrounding waters. The data used in our study include the Shuttle Radar Topography Mission (SRTM) digital elevation models (DEMs) [15], and Landsat MSS/TM/ETM images (Table 1). The Landsat images are sourced from Global Land Cover Facility in University of Maryland (http://glcf.umd.edu/). The TM false color images in research region are showed in Fig. 1.

Table 1. Parameters of the used Landsat images.

Date	Image type	Resolution	Bands	Wavelength	Orbit	Frame
1979-10-13	MSS	60 m	4	0.5–1.1 μm	131	044
1990-10-13	TM	30 m	7	0.45–2.35 μm	122	044
2000-09-14	ETM+	30 m	8	0.45–2.35 μm	122	044
2003-01-10	ETM+	30 m	8	0.45–2.35 μm	122	044
2005-11-23	TM	30 m	7	0.45–2.35 μm	122	044

2.2 Method

We group the land cover in Shenzhen into four classes, including urban land, vegetation, bare land and water. In some studies, the vegetation is further divided into subclasses

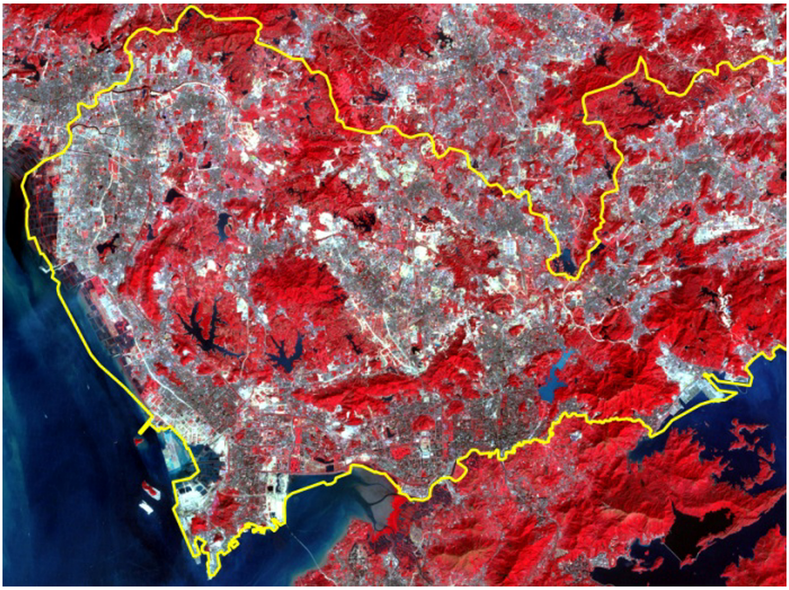

Fig. 1. The TM false color image in research region.

like forest land, wetland, orchard, and grassland [16]. With the development of remote sensing techniques, there are lots of classification methods, like decision tree, k-nearest neighbor, and artificial neural network [17–19]. Among these methods, support vector machines algorithm is a machine learning method based on statistic studying theory, which has good performance in the situation with limited training sample. It can solve some classification problems existing in other methods, such as small-sample, devilishly learning, and big-dimension [20]. Previous study has compared the support vector machines with maximum likelihood and artificial neural network in classification on Landsat image [21]. The results reveal support vector machines outperforms other methods in terms of better classification precision. We also tested other methods in our study. Therefore, we adopt support vector machines method to classify the Landsat images in this paper. Here Gaussian function is set as the kernel of support vector machines and the parameter γ is set as the reciprocal of band number:

$$K(x_i, x_j) = e^{-\gamma \|x_i - x_j\|^2} \tag{1}$$

The previous classification methods cannot give a satisfactory solution to such problems. In order to ensure the classification accuracy, manual intervention was implemented on the classification. We corrected the affected areas by using of visual interpretation.

3 Results

First, we classify the Landsat images based on support vector machines with assistance from visual interpretation. We obtained five land cover maps during the period from 1979 to 2005 (Fig. 2).

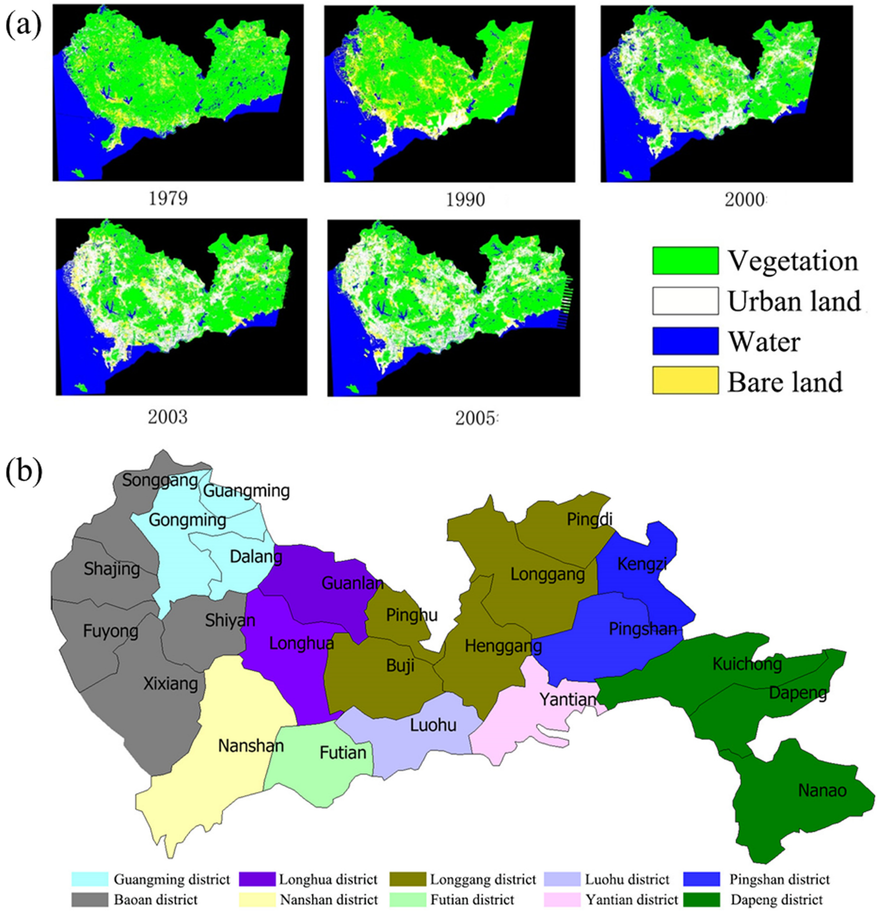

Fig. 2. The land cover maps in Shenzhen from 1979 to 2005 (a) and administrative map (b).

Then, we apply a statistical analysis on the land cover change. It is found there is an acceleration in the rate of urban land growth from 1979 to 2003. The vegetation drops the most rapidly from 2000 to 2003. It shows the urbanization in Shenzhen is implemented at a cost of vegetation reduction. The water area types in our study region include reservoir, river and sea. Figure 2 shows that the water areas exhibit the trend of falling down from 1979 to 2003. It indicates that the reclamation activity is the main factor to affect the water area in Shenzhen. Between 2000 and 2003, the increase of urban land mainly happened on Baoan and Longgang districts. In 2005, the land use change is still dominated by urbanization in outlying districts and reclamation in central districts.

4 Discussions

Most studies use the transfer matrix to describe the characters of land cover change among classes, but it is still not intuitive and easily understood, the complex network approach is an important method for the study of sociology and informatics [22, 23]. We make use of this method to describe the shift between different land cover classes in Shenzhen. Each node in the network represents a land type. Figure 3 is the complex network visualization of the land cover transformation between the five observation time points. It can be clearly seen that the transformation from vegetation to bare land dominates the land cover change during 1979–1990. The medium of bare land during the urban construction can hardly be witnessed, even though the time intervals are shorter than the two periods before. It reveals the transformation from vegetation to urban becomes faster.

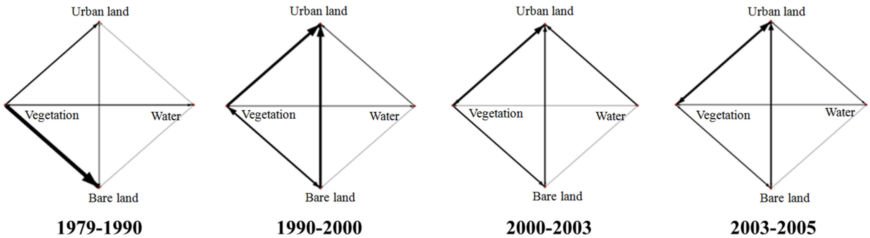

Fig. 3. Complex network visualization of land cover transformation in Shenzhen from 1979 to 2005.

5 Conclusion

In this study, we develop a classification method of land cover based on support vector machines by use of Landsat images. As a case study, we retrieve Shenzhen land cover maps in five timing points from 1979 to 2005, and then take use of the complex network approach to analyze the character of land use-cover change from an overall perspective. The complex network visualization shows that the main changes of land use-cover are different over time. The medium of bare land during the urban construction can hardly be witnessed, even though the time intervals are shorter than the two periods before. It reveals the transformation from vegetation to urban becomes faster. The transformation from vegetation to bare land is hard to be witnessed in the late stage. As bare land is the medium for transforming vegetation to urban land in Shenzhen during the past years from 1979 to 2005.

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