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The application of very high resolution satellite image in urban vegetation cover investigation: a case study of Xiamen City

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With the technological improvements of satellite sensors, we will acquire more information about the earth so that we have reached a new application epoch of observation on earth environmental change and cartography. But with the enhancement of spatial resolution, some questions have arisen in the application of using traditional image processing and classification methods. Aiming for such questions, we studied the application of IKONOS very high resolution image (1 m) in Xiamen City on Urban Vegetation Cover Investigation and discussed the difference between the very high resolution image and traditional low spatial resolution image at classification, information abstraction etc. It is an advantageous test for the large-scale application of very high resolution data in the future.

The application of very high resolution satellite image in urban vegetation cover investigation: a case study of Xiamen City CHENG Chengqi, Li Bin, MA Ting (Institute of Remote Sensing & GIS, Peking University, Beijing 100871, China) 1 Introduction Beginning with the launching of the first American earth resource observing satellite, through 30 more years´ development, the capability and technical parameter have been greatly improved for remote sensing satellite. As to the spatial resolution, it is enhanced from 30-60 m to IKONOS 1 m in 1999; as to the time resolution, it is shortened from 15-18 days to 2-3 days; as to the spatial resolution, it is developed from the original 4 bands of Multi-Spectral Scanner to 192 continuous spectral bands of High Resolution Imaging Spectrometer (HIRIS). The kinds of sensors are also increased from visible light and multi-spectra to radar which now can provide data in all weathers and the basis is established to collect accurate data in all weathers for the application of remote sensing in many practical fields. And that very high resolution data demands new theories to process and acquire information for its particular characteristics which are different from traditional remote sensing data (Ma, 2001; Pu and Gong, 2000). Nowadays many countries have made their plans on high resolution remote sensing satellite for the large latent market and application value. In this paper we used IKONOS very high resolution satellite image. IKONOS satellite was launched by Athena II Satellite of Lockheed Martin on September 24, 1999, and is managed by Space Imaging. IKONOS satellite is hitherto the most complicated remote sensing satellite and the first commercial remote sensing satellite of 1-m resolution. The main effectual load of IKONOS satellite is digital image sensor. It can gather panorama image of 1-m resolution and multi-spectrum image of 4 m resolution. Multi-spectrum image will reveal information that cannot be seen by naked eye, such as the amount of chlorophyll, chemical substance, infiltrating coefficient of ground water. By reason that the satellite sends digital image signal, the images can be fast processed and be used in the applications with drastically restrictive time limitation (LSA, 1999). 2 Materials Receiving the commission of the Environmental Protection Agency of Xiamen, the Landscape Bureau of Xiamen and the Information Harbor of Xiamen, the Institute of Remote Sensing and GIS in Peking University has undertaken the project to use IKONOS image to investigate and analyze the current situation of urban vegetation cover of Xiamen. The purpose is to give evaluation to the virescence structure by precisely computing area of virescence, virescence rate and distribution of the city. In this project we considered the ecological function and peculiarities of vegetation and classified the vegetation into 3 kinds. The first kind refers to the sequential areas that are constituted by arbor, shrubbery and meadow. Such areas have the best ecological stability and larger Leaf Area Index (LAI), and will cleanse atmosphere and provide place for people to play and relax; the second kind refers to the areas that are constituted by meadow and sparse arbor or meadow and shrubbery, which have comparatively well-proportioned distribution; and the third kind refers to the areas that are constituted on ly by meadow or sparse arbor. Such areas are presented in the remote sensing image as large discontiguous fragmentary pea green areas and the ecological stability is frangible and ecological function is the worst. This kind of areas should be paid more attention to its virescence. In this paper we were mainly involved in the statistic research on the virescence areas. The data we used in this research are: (1) IKONOS very high resolution image. The imaging time is September, 2000. But the quality of these images is not very good mostly because there are large areas of cloud (Figure 1) and shadow of buildings caused by the imaging time and sun angle. It has brought difficulties to image interpretation and we will discuss such difficulties in the following text. (2) Vector map of Xiamen administration. It is used for the assistant to select training area and correction of interpretation by naked eye, and obtains the administration ambit of Xiamen to define research area. (3) Other statistic data about virescence investigated on the spot, such as distributing situation of virescence rate and statistic data about virescence in residential area in the years 1995 and 2000. 3 Image processing There are many researches on traditional remote sensing image in urban application (Hsu, 1976; Ju et al., 2002; Li and Han, 2001; Ogrosky, 1975; Qin et al., 2001; Wan and Xu, 2001), but there are few researches on application of very high resolution remote sensing (Boekaerts et al., 1999; Charalambos, 1999; Tuomas et al., 1999; Wang and Zhu, 2000; Zhang et al., 2000). In this study we used the ERDAS IMAGINE and the traditional supervised classification method of Maximum Likelihood. Because there is a lot of information about water, road etc. which is similar to that of vegetation, some work must be done for data-preparation such as deletion of water areas, rectification of image and vector data, image resampling and histogram matching etc. In data-preparation we find that the coverage of cloud and the shadow of cloud and high buildings influence classification and we cannot accurately compute the virescence area. On the basis of the investigation data on the spot, we divide the influenced areas into different styles and set different virescence coefficients to each style. The whole process is shown in Figure 3. According to the degree that the area is influenced and the data investigated on the spot, we divide Xiamen into the following styles: (1) Visual virescence area. It refers to the virescence area without cloud or shadow of high buildings, such as public lawn, scholastic playground, aerodrome and mountainous region etc. This style can be seen directly in the original image and be computed accurately in the classification map. This style includes most of the lawn and mountainous region. (2) Cloud area. It refers to the area that is shaded by cloud. This style can be further divided into 3 parts. The first part is the cloud over urban area, the second is the cloud over mountainous region, and the third is the cloud over badlands and farmlands that are not considered as virescence areas in this study. (3) Shadow area. It refers to the shadow of buildings that will be mistakenly classified as virescence area due to the influence of buildings. This style also contains 3 parts, old urban area, new urban area and high-class residential area. Most of the buildings in old urban area are low especially in the west of Kaiyuan District. The virescence rate in this area is also low. The virescence rate is better in new urban area and buildings in this area are high and in order. It is very easy to distinguish between old urban area and new urban area in the original image. High-class residential area refers to the newly-built, reasonable programmed residential area, which is distributed on the skirts of the city with high virescence rate, small area and scattered distributing. (4) Road. It mainly refers to the main traffic roads with greenbelt, but it is difficult to distinguish them in interpretation. (5) Non-statistic area. The rest area except the areas mentioned previously, including water, farmland and badlands. We sketch vector layer to each area of different styles and build topology. According to the investigation data on the spot, we set a coefficient to the area of each style and compute the virescence area of each style. The coefficient and the final results are shown in Table 1. 4 Questions and discussion 4.1 Data preparation As to the 1 m resolution panchromatic image, the spectral characteristic of water, road and shadow of high buildings and cloud is similar to that of vegetation, especially between the water and lawn. If we classify such image without data preparation, it cannot but result in larger probability of erroneous classification. It is necessary to make data preparation, for example, delete the water area in the image before classification. But as to the shadow of buildings and cloud, we cannot simply delete it because we do not know where there are virescence areas under the shadow. And this problem cannot be slid over in application of very high resolution satellite image in the future. In our study we set different coefficients to solve this problem and it seems efficacious. We expect more appropriate method in future research. 4.2 Processing of large amounts of remote sensing data Processing method of large amount of remote sensing data is one aspect of research on very high resolution satellite image (Ma, 2001). The amount of traditional TM and MSS image is only about 1/10 of that of very high resolution image. In our study the image we used is aggregately 1GB. So large amounts of data demand higher standard for software to process. It takes 30 more minutes to open the 1GB IKONOS image in ADOBE PHOTOSHOP. It only takes few seconds to open the image in ERDAS IMAGINE, but a supervised classification costs about 40 minutes. And some processing in MapInfo cannot be done for so large data, for example, when overlay image with vector data and zoom out to a certain degree, the image will disappear. So we must use some method such as dividing the image to small ones to solve this problem before software is materially improved. 4.3 Comparison of remote sensing data in different years Figure 4 compares the remote sensing data of different resolution in the years 1995 and 2000. Data in the year 1995 and December of 2000 are SPOT data of 30 m resolution (YXC, 2001). We find that the virescence rate computed by very high resolution data is bigger than that computed by traditional data. Analyzing the causation, we think the very high resolution image detailedly describes the characteristic of landscape. Compared with traditional data, the very high resolution data can compute information that cannot be seen in traditional image, such as virescence area between buildings and along roads. 4.4 Prospect to the application of very high resolution image The emergence of very high resolution remote sensing image represents the new development stage of remote sensing satellite in the 21st century (Li, 2001). But very high resolution image also demands new techniques for image processing. The traditional processing techniques will not be practicable and all the problems cannot be resolved only by one kind of technique. We must combine the machine vision image processing, fractal, multi-data fusion and large amount of data processing; make the most support of GIS and GPS; unite the energy information acquired from remote sensing and substance information not acquired from remote sensing to resolve quantum problems in application (Ma, 2001; Liu et al., 1998; Zhang and You, 1998). The very high resolution image has a spacious prospect in application on cartography, meteorology, environmental protection, resource investigation and sporadic affairs management.

关键词： high resolution remote sensing; vegetation cover investigation

