地理学报(英文版) 2003年第13卷第4期

An applied research on remote sensing classification in the Loess Plateau

作者: LIU Yongmei TANG Guoan

Due to complex terrain of the Loess Plateau, the classification accuracy is unsatisfactory when a single supervised classification is used in the remote sensing investigation of the sloping field. Taking the loess hill and gully area of northern Shaanxi Province as a test area, a research was conducted to extract sloping field and other land use categories by applying an integrated classification. Based on an integration of supervised classification and unsupervised classification, sampling method is remarkably improved. The results show that the classification accuracy is satisfactory by the method and is of critical significance in obtaining up-to-date information of the sloping field, which should be helpful in the state key project of converting farmland to forest and grassland on slope land in this area. This research sought to improve the application accuracy of image classification in complex terrain areas.

An applied research on remote sensing classification in the Loess Plateau LIU Yongmei1,2, TANG Guoan1,3, LI Tianwen 1, YANG Qinke2 (1. Department of Urban and Resource Science, Northwest University, Xi´an 710069, China; 2. Institute of Soil and Water Conservation, CAS and Ministry of Water Resources, Yangling 712100, China; 3. The Key Open Laboratory of Continental Dynamics, Ministry of Education, Northwest University; Xi´an 710069, China) 1 Introduction The Loess Plateau is well known for its rich mineral resources and great development potential, but suffers seriously from soil erosion. Especially in recent years, with the aggravation of economic activities, ecological environment in the region has kept on deteriorating and the land resources have been dramatically destroyed. In order to expand farmland, a large area of forest and grassland on the steep slope land has been destroyed for reclamation and cultivation. Apart from a small quantity of loessic flat land and plain, which are relatively flat and available for farming, most of the farmland in the region is sloping field. Published statistic documents show that the area takes 90% of the total area. In addition, it is because of the sloping fields with great gradients (usually over 25o) that accelerate soil erosion and environmental degeneration. In order to reconstruct ecological environment in the Loess Plateau area and develop sustainable economy, a national key project of "Converting Farmland to Forest and Grassland" has been issued and carried out in recent years. The steep sloping field (gradients over 25o) will be gradually converted to forest or grassland. In this process, the remote sensing image classification technology is an important means of providing up-to-date and reliable information on spatial distribution and magnitude of the sloping field. Therefore, a specially designed classification method should be of great significance in this application. Of the two common remote sensing classification methods--unsupervised and supervised classifications, supervised classification is most popular in researches and applications. However, supervised classification has many limits for it is mainly based on the spectral characteristics of the objects. Therefore, many improved classification methods have been put forward, which proves to be of high classification accuracy (Congalton, 1991; Guan and Liu, 2001). Nevertheless little was done in improving the image classification method in the complex terrain area, e.g. the Loess Plateau area. Taking loess hilly and gully area of northern Shaanxi Province as a test area, this work extracted the sloping field and other land use categories by employing an integrated classification, which is an integration of both supervised classification and unsupervised classification. The result shows that the classification accuracy is greatly improved by applying the new method, so that it shows a splendid application future. 2 Research basis 2.1 Test area The test area is located in the watershed of Wuding River, a main substream of the Yellow River. It covers an area of 1062 km2, ranging between 109o40´00´´E- 110o10´00´´E and 37o6´00´´N- 38o10´00´´N. It is a typical loess hilly and gully area, where the gully erosio n and gravitational erosion are active and gully is fully developed which tears the original flat ground into separated pieces. The mean gradient is 28.7o with steep slope (over 25o) taking 60% of the total area. In recent 30 years, the area has been taken as a national key-harnessing region for the water and soil conservation (Figure 1). 2.2 Test data The test data adopted in the experiment includes: (1) Rectified Landsat TM image data (7 bands) of the test area acquired on June 13, 1997; (2) 1:100,000-scale land-resources map of the test area (1997, vector data); and (3) other thematic data, e.g. land resources data, gradient data as well as soil erosion data. 3 Image preprocessing (1) Principal Components Analysis (PCA for short): First, PCA is performed on 7 bands of the Landsat TM image data. Then, the first three bands of the PCA image are selected in order to compress data and reduce data redundancy. Furthermore, performing PCA on the image can eliminate the effect of the shadow derived from rough terrain in some degree. (2) Inverse Principal Components Analysis (IPCA for short): In order to improve the recognizability of the PCA image, the IPCA should be performed on the first three bands of the PCA image and thus they can be transformed to RGB space. Finally, 7 bands of the IPCA generated in the operation are adopted as data source for the classification. 4 Experiment 4.1 Classification system Table 1 shows the classification system. 4.2 Classification method Supervised classification can extract main land use categories with certain accuracy. The main disadvantage is: it is difficult to select adequate and representative samples manually because the phenomena that the same objects have different spectral characteristics or different objects have the same spectral characteristics appeared in many situations (Qiao, 2002). As mentioned above, deep gully and steep slope are the major terrain characteristics in the loess hilly and gully area. The solar radiation is redistributed on different terrain positions, hence a strong contrast of the image tone appears between the adret and the opaco. The gradient of the sloping field varies greatly, as a result, the tones of the sloping fields are diverse on the image. If the single supervised classification is adopted, much more work should be done for the selection of training samples and it is hard to obtain all samples of the sloping field. Furthermore, it will influence the classification accuracy. A specially designed method, integrated classification, is adopted in this research. The experimental result shows the method could not only increase classification speed but also improve classification accuracy. Figure 2 shows the steps of the integrated classification. Firstly, an unsupervised classification is performed on 7 bands of the IPCA image to generate an initial sample set automatically. Secondly, individual classes in the set are identified based on field check, original image, land use map as well as other relative data. Incorrect samples are deleted, samples omitted supplemented, and the samples belonging to the same category merged. The steps should be repeated until the sample set can accurately reflect the spectral characteristics of the categories. Thirdly, based on the final sample set, a supervised classification is performed to generate land use thematic layer. Finally, the classification accuracy should be evaluated. 4.3 Training sample evaluation The selection of training samples is a key performance to the classification. According to the classification system, 40 initial samples are generated by the unsupervised classification. After adjusting the samples repeatedly, 74 samples are selected for 5 categories finally. Of them, 26 samples belong to sloping field. The histograms of the samples suggests that there is a high spectrum separability between sloping field and the rest categories, especially in the first three bands of the IPCA image (Figure 3). The samples contingency matrix records the correctness percentages that indicate how many pixels in the samples of each class were assigned to expected class. Table 2 shows the value of each class is over 80%, which is an ideal identification result for each class. The values of forest (grassland) and sloping field are over 90%, showing a high identification rate. The spectral characteristics of the plain, settlement area and water area are more or less similar to forest (grassland), so a small portion of mixture could be found in the classification. The sample pixels of 8.6% plain, 9% settlement area and 7.5% water area were assigned to forest (grassland). After the above operation, the supervised classification is performed by the rule of Maximum Likelihood to generate the thematic layer and it is recoded. Then the area statistics of the final result is achieved (Table 3). 5 Result and discussion It is a necessary post-classification work to assess the classification accuracy. First, the land use map is overlaid to the classification result. Figure 4 indicates it is a well match. Stratified random sampling is applied in the assessment. The method ensures direct ratio of random points to pixels of corresponding class and the maximum of 10 points for each class. Two hundred random points are selected in the area. Compared to ground truth data, land use map and other data, every point is determined. Table 4 shows the classification accuracy assessment. 6 Conclusions (1) Compared to manual interpretation, auto-interpretation is superior in its speed, accuracy and less demand of labor work. Therefore, the auto-interpretation method is recommended as an essential technical method in ecological environment investigation and dynamic monitoring. (2) Roughness terrain would cause a complexity in the classification because same objects usually have different spectral characteristics on remote sensing data. It is hard for the single supervised classification to bring a practical result. In this research, the author employed the integrated classif

ication in the loess hilly and gully area, so that many obstacles, like blind manual sampling, high demand of labor work, are solved. A satisfactory result is achieved with the total accuracy of 88.00% and sloping field accuracy of 92.73%. (3) The shadow area derived from hilly region can not be auto-classified merely based on the spectral characteristics of the objects. In addition, more problems, such as different objects with the same spectrum, still remain unsolved. It is a dramatic weakness of integrated classification. Therefore, Digital Elevation Model (DEM) data need to be adopted in further researches.

关键词： remote sensing; integrated classification; loess hilly and gully area; sloping field; Shaanxi

