Classification Method Research to Remote Sensing Images

Yu-liang QIAO(乔玉良)
(*College of Mining Technology*, *Taiyuan University of Technology*, *Taiyuan* 030024, *China*)

Abstract – With rapid development of remote sensing technology, the resolution of remote sensing images is increasingly improved; then people can extract more useful data and information from these images. Thus, an important information extraction method from remote sensing images – image classification, becomes more and more important. Based on phenophase and band composition characteristics, this paper firstly discusses the important role of background parameters in remote sensing images classification; then based on geographical information system technology, the computerized automatic classification to high-medium-low-yield croplands in Dingxiang County of Shanxi Province in remote sensing images has been carried out by using compound layers classification method of multi-thematic information; compared the classification result to the visual interpretation results, the accuracy increases from 70% to above 90%.

Key words – *remote sensing classification*; *background parameters*; *thematic information*; *band composition*; *geographical information system*

Manuscript Number: 1674-8042(2010)04-0317-06

dio: 10.3969/j.issn.1674-8042.2010.04.04

1 Introduction

Remote sensing images record and represent the electronic radiation information of ground objects according to a certain scale, which are important form of remote sensing information acquired by remote sensors[1]. Hence, the key issue of remote sensing technological application is to interpret the attributes and distribution characteristics of ground objects based on the representing features of the electronic radiation degree of the ground objects in the remote sensing images[2]. The features of remote sensing images are decided by many factors, such as remote sensing detecting channels, spectral characteristics of ground objects, atmospheric transmission characteristics and the response features of remote sensors[3]. As long as we understand the impact of these features on the characteristics of remote sensing images, the classifications to remote sensing images can be conducted based on the attributes and distribution area of ground objects in remote sensing images.

Remote sensing classification is mainly based on spectral characteristics of ground objects – the multi-band measured values of electronic radiation of ground objects, which can be used as original characteristics variables of remote sensing classification. Classification is conducted by the similarity degree of brightness of every pixel in remote sensing images, so as to distinguish different kinds of ground objects in the images[4-6].

Conventional remote sensing classification methods by computer are either supervised or unsupervised classification, such as maximum likelihood classification, mini-distance classification and multi-group distinguishing classification. Although these methods are valuable in distinguishing primary objects, they have also obvious weaknesses. Many errors and losses may be brought about in conventional computerized classification methods. In the conventional methods, computer automatic-classification relies only on spectral data of remote sensing, and the important spatial and geographic information and their relationships are neglected. But we know that they are very important for cropland classification. With the development of Geographic Information System (GIS) technology, geographic information plays an important role in overcoming the same spectra of different objects to improve the accuracy of classification. In the experiment, taking Dingxiang County for study area, remote sensing monitoring and study are carried out on high-, medium- and low-yield croplands in Loess Plateau through composite hierarchical classification method of extracting thematic information, classification in sub-regions and combine them at last; then, analyses are made of the application of the background parameters of remote sensing classification in spatial information. They not only correct the errors of the conventional remote sensing classification method, but also provide a scientific and effective way for improving the accuracy of conventional remote sensing classification.

* **Received**: 2010-09-20
Corresponding author: Yu-liang QIAO(proqiao@126.com)

2 Applied analyses of the background parameters of remote sensing classification[7]

The ground resolution, spectral resolution and temporal resolution of the image are the basic attributes of remote sensing information. In remote sensing applications, they are always the norm of image evaluation. Furthermore, they always improve the accuracy of the classification in ground objects recognition if the features of phenophase of the image temporal phase of studied objects are analyzed.

2.1 Phonological analyses of the object's recognition and the classification image

Attention must be paid to the features of phenophase of the image's temporal phase, and the temporal resolution is regarded as the basic guarantee in object recognition. This is the important basis to ensure the mapping quality of spatial image. The objectives of the application of the temporal resolution in remote sensing are:

1) To fully expose the image features and laws of the recognized ground objects with the optimum temporal phase, so as to improve the image interpretation rate and its discrimination degree.

2) To dynamically monitor and analyze the changes and developments of resource and environment factors by using the temporal differences of the ground objects' images. They have been widely used in effectively getting ground object types, estimating the yield of crops and dynamically monitoring and analyzing the historical evolution of the factors of the natural environment (such as river system, lakes, and vegetation).

3) To know that it is closely related between objects' characteristics and their phenophase, and various types of ground objects, including crops, have their specified phenophase. For example, rice, wheat, and maize all undergo the growing processes of tillering, jointing and earring. Woody plants experience stages of sprouting, leaf-out spreading, blooming and leaf-falling, etc. (Tab.1).

In selecting, estimating and extracting the area of planting wheat, in the first place, the features related with the distribution regions should be taken into consideration. In the second place, the ecological features of the whole growing period from seedlings to sprouting, from turning green to mature, should be studied. Meanwhile, the phenophase of the crops should be analyzed, with the requirements of the extracted object. Regarding the winter wheat in North China Plain, from mid November to mid December, the growth of the wheat through the winter is 3 cm～4 cm, during which the vegetation except needle-leafed forest has nearly withered and fallen, thus the background is suitable for collecting the information of winter wheat. It can be the right time for determining the planting areas for winter wheat. But during the period from March to April in the next year, winter wheat is in the stage of turning green and jointing. In early April, winter wheat is going into the phenophase, and at this time, the vegetation coverage is increased, but compared with the target and background, the green degree of winter wheat is between that of forest and spring weeds, so it is much easier to differ the winter wheat from other crops. And the period from jointing to earring is the key phenophase for the member of wheatears. Therefore, the image before mid December is best for extracting wheat planting areas. For estimating the yield, the images of early and mid April should be selected. Of course, for the best selection of the temporal phase, the cloud amount sh-

Tab.1 The phonological temporal analysis of the image interpretation in some regions[8-10]

Target of Ground object		Phenophase			Image of optimum temporal phase	Remarks
		The early phase of tilering	Early phase of jointing	Ears-put getting		
Wheat	Winter wheat	Oct.11～21	Apr.11～21	Early May	Mid Nov.～Mid Dec. or Apr.～May	Taiyuan, Shijiazhuang, Tianjin, Beijing regions
	Spring wheat		Late May～before Jun.1	Mid Aug.～Early Sept.	Late May～Early Jun.	Shenyang, Changchun, Ha'erbin regions
Maize	Spring maize	About May 21 (3 leaf phase)	About Jun.20		Mid Jun. or Apr.	Beijing, Shenyang regions, etc.
	Summer maize	About Jun.11 (3 leaf phase)			Mid Jun.～Late Jun.	Chengdu region
Rice	Early rice			About Jun.29	Mid June	South regions
	Mid rice			Early Aug.	Mid August	
	Late rice			Mid Sept.	Mid September	
Saline or alkaline soil		Phase of gathering saline Mar.～Jun., Sep.～Nov.	Mid Apr. Winter wheat jointing		Late Mar.～Early Jun., Late Sep.～Early Nov.	Dezhou region
Forest & grassland		Leaf spreading phase Mid Apr.			Nov. Or Mid Apr. July～Aug.	North regions

ould be considered, so when selected, the time can change in a certain range, and other platform images can be used in the right time[11].

The bearing period of rice is between May and October, during which other vegetation is also growing luxuriantly. The early rice grows from the end of April to late July, and ears at about June 20; Mid rice grows from late May to early September, and ears at about early August; Late rice grows from the end of July to the end of October, and ears at about mid September. The earring period for rice is the important phenophase concerning the rice yield. The periods of bearing and earring as the best time for extracting the areas for planting rice are usually selected. From the above-mentioned, the different crops have a certain phenophase as the vital phase to influence their growth and yield, which is the major basis for selecting the image of the best time and thus, a basic guarantee for the accuracy of the ground object recognition and classification. One thing that should be paid attention to is that the best temporal phase of the image classification and recognition of different crops changes with the regions, since the same type of crops has the different phenophase in different regions, such as the different phenophases in different regions for winter wheat (Tab.2).

Tab.2 Different phenophases of the winter wheat in different regions[12]

Phenophase	Beijing	Nanjing	Chengdu	Nanning	Wulumuqi
Early stage for tillering	Late October	Mid November	About Dec.11	Before Dec.21	About Oct.11
Early stage for jointing	Before Apr.21	Mid March	About Feb.1	After Jan.1	About May.1
The earing stage	Before May 21	Mid April	Mid March	About Feb.1	About Jun.1

In addition, in the classification of land uses, all kinds of ground objects have different ecological environments and different best temporal phases of image recognition. For example, the growing period for the grass is from May to August, and the greening period is from mid spring to early summer. Therefore, in the process of recognition and extraction of the single factor for grassland, the selection can be done according to its regional features and background factors.

2.2 Analysis of the optimum composition of bands of the thematically classified images

To carry out image interpretation and mapping by using multi-spectrum information can widen the applied field. Theoretically, in selecting the multi-spectrum, more bands and narrower width make the image information more, and it is advantageous to the analyses of subtle differences among the ground objects. The more narrowly the wave bands are divided, however, the greater the relativity among the data from the bands. It increases the degree of trivial details, and adds to the amount of dealing with image information. So it can ensure the accuracy of classification and the quality of mapping, to comprehensively analyze multi-factors and to reasonably choose the effective wave bands according to mapping targets, and to optimally compose the bands with reasonable purposes.

With the development and application of the multi-spectrum information and the technique of the image spectrum (or the technique of remote sensing of the narrow spectrum band), in the analysis of thematic processing and the study of cartography, the selection of the bands is more important to the purposeful recognition of the ground objects. For instance, in the analysis of the vegetation elements, if the bio-chemical elements (as vegetation cellulose, etc.) are studied, to select the image of spectrum from 0.45 μm to 0.60 μm, more obvious effects will be achieved. Besides, when exploring the productivity according to the capacity of the vegetation chlorophyll and get an effective result will be obtained by using the spectrum data of mapping and selecting the composition of bands from 0.52 μm to 0.60 μm and from 0.76 μm to 0.90 μm to carry out the regression analysis.

However, the different objects studied differ in the pertinence, effectiveness and composition for the choice of the spectrum bands. The selection should be done according to different objects and aims. Different selections are reflected in the applications of different fields, such as agriculture, forest, water resource, ecological environment, city, etc.

The application of the bands should be firstly aiming at the recognized target, to make an analysis of choosing available bands, and then to make the optimal combination or collect comprehensive information by using image bands from different platforms. As is known, the brightness degrees of the image of ground objects are strikingly different. For example, water and swampy grounds have the low quality of the brightness; I_{cy} and snowy grounds, sand beaches, sandy grounds and other exposed grounds have the high quality of brightness; Crop grounds, forest grounds, bush grounds and grasslands, etc. generally have the medium brightness. According to the sensitivity of the objects to different bands (TM2, TM3 are more sensitive to chlorophyll; TM4 is well reflecting the vegetation denseness; MSS 5 and 7 bands have a good performance in agricultural lands; SPOT3 is the main band of the distinguishing needle, and wide leafed forests; SPOT1, TM2, MSS4 are green reflecting peak of the vegetation), at the same time, the bio-features of the crops should be considered (the period when the obvious differences take place for the winter wheat is from the end of March to the beginning of June; In the seedling period, to distinguish the spectrum for the wheat growth is good; After blooming and earring to distinguish the spectrum for the wheat growth is not so ideal), together with the representational differences of the crop spectrum by different bands and

the amount of information, the relativity, the effectiveness and the limitations of the bands. By doing so, the optimal combining schemes can be arrived at.

In practice, the composite scheme by standard false colors are usually adopted, MSS7, 5, 4 (matched by R, G, B), and TM4, 3, 2(matched by R, G, B);SPOT 3, 2, 1 (matched by R, G, B). So, when the different compositions of the different bands of the objects are used, the key is to carry out the optimal composition of multi-bands according to different objects. Usually 3 bands are selected, because if the more bands, the more amount of information and noise errors. Therefore, through geo-scientifical and biological analyses, it is an economical and effective way to compose the bands of ground objects by using "overlapping spectral images".

Besides, based on the different aims of the applications, the multi-temporal spatial information, the multi-platform image information, the remote sensing information and non-remote sensing information, etc. can be composed, by making full use of different information features, so as to get the most effective information, and to achieve the greatest effectiveness of the discrimination of ground objects.

3 Realization of high-, medium- and low-yield croplands classification[13]

Remote sensing classification to high-, medium- and low-yield croplands is the research field of the satellite application project of the Commission of Science. In remote sensing classification, Dingxiang County of Shanxi Province is selected as the experimental area. In order to understand the formation factors of the medium- and low-yield croplands completely, the field exploration in Dingxiang County has been carrid out, and it is believed that the factors of the medium- and low-yield croplands in Dingxiang County can be divided into drought pattern, salinity pattern and the loss (soil and water) -destruction pattern. On the basis of comprehensive analyses, combined with the complication and murkiness in dividing the medium- and low-yield croplands, the influencing factors of classification index are divided into the grades of irrigation, the extents of salinity and angle of the terrain slope, and conduct multi-thematic information divisional compound hierarchical classification[14].

3.1 The band selection and initial classification

In the colour infrared aerial photographs with a scale of 1:19000, the training areas are chosen by the means of disintegration and returning back in classification on the basis of the real conditions in ground investigation and expert experience. For example, the high-yield cropland can be divided into stable and usual high-yield cropland[15]. The training areas are chosen separately and their own patterns are formed in computer recognition and classification, then the stable and usual high-yield croplands are amalgamated into high-yield cropland in land pattern dimension statistics.

In initial classification, the extraction of the feature of the crop living conditions is focused on, and the TM data in use is just August, so the high-, medium- and low-yield croplands have a close relation with it. Infrared-red, infrared/red and (infrared-red) / (infrared + red), that is, (TM5-TM3), TM5/TM3 and (TM-TM3) / (TM5 + TM3), are used to analyze the training areas chosen.

After evaluation, six types in the field are determined, that is, high-medium-low-yield farmland, residents, water and non-cropland. Therefore, the results of the initial classification are obtained.

3.2 The extraction and introduction of thematic information

In order to fully take advantage of expert system and GIS, the thematic information is extracted layer by layer. In the course of the classification, the information is introduced such as topographic characters, irrigation, and soil salty and so on, and different thematic layers and auxiliary information are introduced aim for the results of initial classification.

3.2.1 The extraction and introduction of irrigation information

The introduction of the thematic information about irrigable land classification is that the thematic TM image with the scale of 1:50000 is combined with the colour infrared aerial remote sensing information, whose grey degree of pixel can be divided into 4 grades after matching and gridding, which can be divided into first-grade irrigable land, second-grade irrigable land, third-grade irrigable land and dry land. The distribution of the high-, medium- and low-yield croplands have close relation with the irrigation time, and the volume of water; The high-yield cropland is first-grade irrigable land which can be irrigated twice a year; The medium-yield cropland is second-grade irrigable land which can be irrigate once a year; The low-yield cropland is third-grade irrigable land which has the system of the ditch but doesn't has promising water sources.

They do not correspond to the high- and medium-yield croplands completely, however, all the first-grade irrigable croplands are often high-yield croplands based on the investigation. Therefore, the information of the first-grade irrigable cropland is extracted, which will be compounded to the classification in practice.

3.2.2 The extraction and introduction of salinity information

Saline soil includes salt-soil and alkali-soil. Because the excessive amount of the salt and alkali in the soil will make the crop need more water, the yields of the cropland will certainly be low.

The saline croplands is analyzed by different means, because some are farmland and others not. To the waste-

land, it is judged by the homogeneous and deep extent of the white colour on the infrared aerial photos and the concentration of the salt in the surface soil. There are evident appearances, evident crops and trees on the saline soil. It is judged mainly by the coverage-degree of the plants and the deep degree of the colours because of the plants′ grown conditions. The one in which the coverage-degree of the plant is above 70% and the red, yellow and green colours are low and not homogeneous is middle-degree salinization; the heavy-degree saline soil is the one in which the coverage-degree of the plant is below 30%. Base on the analyses above, with reference to the colour infrared aerial photos, the distribution thematic map about salinity information with the scale of 1∶50000 is made and interpreted.

In general, the heavy-degree salinization is corresponded with the low-yield cropland. Therefore, the information of the heavy-degree salinization is extracted and compounded with the initial classification to distinguish the medium- and low-yield croplands easily.

3.2.3 The extraction and introduction of the slope information

Dingxiang County is located in the Loss Platte, and the dimensions of the hills are great. So the yield of many slope croplands is low because the slope degree is large, and the water and soil lose heavily, and the conditions of the water and fertilization are bad.

The DEM maps are produced with the scale of 1∶50 000, with the sample distance of 100 m at first when interpreted. With four different kinds of slope layer information introduced: plain (0°～60°), gentle slope (6°～15°), steep slope (15°～25°), very steep slope (>25°), the slope information (>15°) is extracted from the slope layers and compounded with the initial classification to improve the classification accuracy of the low-yield cropland.

The introduction of the remote sensing information and non-remote sensing information can improve the accuracy of the classification effectively[16]. For example, if the cropland is first-grade irrigable land, non-salinity soil and plain, it must be high-yield croplands. The focus of the compounded method is to correct the accuracy of the classification of the high- and medium-yield croplands. The results show that the accuracy of the classification of the high- and medium-yield croplands improves from 63.39%, 61.24% to 85.37%, 86.38%, and the increased extent is 21.94% and 24.96% correspondently through the information extracted layer by layer.

3.3 Method of compounded hierarchical classification

In order to make the method of classification fit for large regions, sub regions are divided in the course of the classification in the whole County. The flowchart of classification is as follows:

1) Considering the soil salinitation and terrain characteristics, Dingxiang County is divided into six sub-regions: ① the high-yield cropland in the alluvial plain; ② the medium- and low-yield croplands in the saline soil; ③ the medium- and low-yield croplands in the flood plain; ④ the medium- and low-yield croplands in the Loess Plateau region; ⑤ the low-yield cropland in the stone-gentle slope; ⑥ the low yield cropland in the stone hills.

2) The classifications in the six sub-regions are carried out separately. Because sub-division results in less number of crop types in each sub-region, interpretating errors resulting from the same targets with different spectra or different targets with the same spectrum can be overcome. The less number of crop types and the small dimensions of the sub-regions will reduce the time of classification in every sub-region, and give the advantage to adjust the training area and correct the different kinds of results. The max likelihood interpretation can take advantage of the statistic features of remote sensing data to get the results of classification with minimum fault probability and max correcting probability by the normal distribution regularity. So the max likelihood interpretation is adopted in every sub-region.

3) Merging the classification resulting maps of the six sub-regions, adding the auxiliary information such as residents' distribution and so on, and correcting the resulting classification maps, the ideal high-, medium- and low-yield croplands classification maps with the scale of 1∶50 000 will be obtained. The advantages of the method of the classification are: ① The complex factors are simplified, and fit for the large area classification; ② The types tend to be simple, so it makes the probability before check possible; ③ The courses of classification and disposal are caried out. For example, the addition of the residents in the soil-stone district shows the advantage of making GIS improve the accuracy the classification.

4 Conclusion

This paper illustrates two methods of thematic information extraction and background parameters analysis to improve the accuracy of remote sensing classification. Their raise and application are new practising production under the development of the integration of remote sensing and geographic information system technology. In the application and research of the background parameters of the remote sensing classification, geographic information system becomes a strong sustaining tool to analyse the spatial data; In the cropland classification of remote sensing monitoring, thematic information extraction and compound hierarchical classification method largely improves the accuracy of remote sensing classification, and the classificaion accuracy increases from about 70% to above 90%, which satisfies the requirements of agricultural production. The conventional remote sensing classification method relies only on spectral information of the pixel, and the important spatial and geographic information and their relationships are neglected; Furthermore, the valu-

able knowledge of the Geo-scientific experts can-not be added into the classification process. The application of thematic information extraction and the analysis of the background parameters can exactly avoid the deficit of the conventional remote sensing classification. The widespread application of these two methods will enlarge the applied field of the remote sensing images, and probe a simple and effective way to the applications of the Chinese resources satellites at the same time.

Reference

[1] M. Baatz, A. Schabpe, 1999. Object Oriented and Multi Scale Image Analysis in Semantic Networks. Proc. of the 2nd International Symposium on Operationalization of Remote Sensing, Enschede. ITC.

[2] A. J. Tatem, H. G. Lewis, P. Atkinson, et al, 2001. Super resolution target identification from remotely sensed images using a hopfield neural network. *IEEE Transactions on Geosciences and Remote Sensing*, 39 (4): 781-796.

[3] X. Yu, I. S. Reed, A. D. Stocker, 2003. Comparative performance analysis of adaptive multispectral detectors. *IEEE Trans on Signal Processing*, 41(8): 235-240.

[4] F. A. Kruse, A. B. Lefkoff, J. B. Boardman, 1993. The spectral image processing system (SIPS)-interactive visualization and analysis of imaging spectrometer data. *Remote Sensing of Environment*, 44: 145-163.

[5] J. R. Jensen, 1986. Introductory Digital Image Processing: A Remote Sensing Perspective. Publisher: Prentice Hall. Englewood Cliffs, New Jersey.

[6] J. C. Harsanyi, C. I. Chang, 1994. Hyper spectral image classification and dimensionality reduction: an orthogonal subspace projection approach. *IEEE Transactions on Geosciences and Remote Sensing*, (32): 779-785.

[7] Su-xing Fu, 1998. Application and analysis of background parameters in thematic mapping by remote sensing. *Research on Geography*, 2: 23-27.

[8] Enpu Wan, 1996. Yield Estimation and Remote Sensing Dynamic Monitoring on Maize in China. Chinese Science and Technology Press. Beijing.

[9] Nai-bin Wang, 1996. Yield Estimation and Remote Sensing Dynamic Monitoring on Wheat in China. Chinese Science and Technology Press. Beijing.

[10] Rui Zhao, 1996. Yield Estimation and Remote sensing Dynamic Monitoring on Rice in China. Beijing: Chinese Science and Technology Press.

[11] Li-ya Xiong, 1996. Integrated System for Crop Remote Sensing Dynamic Monitoring and Yield Estimation in China. Chinese Science and Technology Press. Beijing.

[12] Su-xing Fu, Chong-hou Zhang, Xiou-yun Li, 1996. Regional parameters' application research on classification mapping of image information. *China Journal of Image and Graphics*, 1 (2): 146-148.

[13] Yu-liang Qiao, 2002. Study on classification methods for high, medium and low yield farmlands in loess regions. *Journal of Remote Sensing*, 6(1): 70-74.

[14] Yu-liang Qiao, 2000. Divisional compound hierarchical classification method for regionalization of high, medium and low yield croplands of china. *Adv. Space Res*, 29(1): 89-93.

[15] Yu-liang Qiao, 2000. Study on monitoring farmland by using remote sensing and GIS in shanxi china. *Adv. Space Res*, 26 (7): 1059-1064.

[16] Jiu-lin Sun. 1996. Overall Discussion on Dynamic Monitoring Crops and Yield Estimation in China by Using Remote Sensing. Beijing: Chinese Science and Technology Press.