Study on Extraction of Agricultural Crop Information by Hyperspectral Data

—— A Key Study of Shunyi Area, Beijing

Liu Liang1
China Remote Sensing Satellite Ground Station, CAS
NO.45 Bei San Huan Xi Road, Beijing, 100086, China
lliu@ne.rsgs.ac.cn

Jiang Xiao-Guang2
Academy of Opto-Electronics, CAS
NO.95 Zhongguancun East Road, Beijing, 100080,China
xgjiang@ne.rsgs.ac.cn

Xu Pei-Lai3
China Remote Sensing Satellite Ground Station, CAS
NO.45 Bei San Huan Xi Road, Beijing, 100086, China
plxu@ne.rsgs.ac.cn

Abstract: Remote sensing technology has been widely used in many fields, such as agricultural resource investigation, crops production estimation, disaster monitoring, evaluation and prediction and agricultural information management. People have made rich achievements in these research fields. However, the routine remote sensing technology has shortage to some extent and can't totally meet the higher demand of agriculture. Imaging spectral data with high spectral resolution can discern slighter spectral differences among crops, detect the changes of crops in narrower spectrum range and thus improve the accuracy of distinguishing crops. This paper takes Shunyi District of Beijing as a research area, makes systematical study on imaging spectral data processing and analytical method, and discusses how to use the massive hyperspectral remote sensing data sufficiently and effectively in order to do some researches on agricultural parameter selection and crops information extraction and mining. Based on these, remote sensing technology can serve precision agriculture better and more directly, and we can make intelligent decision and management for modern agriculture.

Keywords: Imaging spectral remote sensing, Agricultural crops, Information extraction, Feature selection.

1. Introduction

After 30 years' effort, remote sensing technology has been broadly used in every field of agriculture, and has brought much economic benefit. It has become a powerful and helpful tool for people to manage agriculture scientifically and promote agriculture sustainable development. However, due to the technical limitation, the routine remote sensing technology has shortage to some extent and can't totally meet the higher demand of agriculture. Agriculture remote sensing mainly relates to agricultural crops. Compared with other ground object types, green vegetation has more spectral intercommunity, so it's hard to be distinguished in routine remote sensing images of wide wave band. Because the spectral resolution of hyperspectral image has been greatly improved, its ability to discern vegetation is obviously better than routine remote sensing data. The fast development of imaging spectral technology is a leap of remote sensing technology in 1990s. It provides a newer and stronger tool for agriculture remote sensing and will greatly promote traditional agriculture to precision agriculture. Finally it will make agricultural science step into a new stage.

Agricultural crops remote sensing is the foundation and prerequisite of agriculture remote sensing. Without accurate crops information extraction (crop types, distribution area, growing condition) we can hardly make agricultural resource investigation, production estimation and disaster monitoring. Imaging spectral data have many advantages which routine remote sensing data can't compare with. It has high spectral resolution so as to discern slighter spectral differences among crops, detect the changes of crops in narrower spectrum range and thus improve the accuracy of distinguishing crops, which is very important to agriculture.

This paper takes Shunyi District of Beijing as a research area, makes systematical study on imaging spectral data processing and analytical method, and discusses how to use the massive hyperspectral remote sensing data sufficiently and efficiently in order to do some researches on agricultural parameter selection and crops information extraction and mining. Based on these, remote sensing technology can serve precision agriculture better and more directly and we can make intelligent decision and management for modern agriculture.

2. General Status of Experiment Area

We select Shunyi District of Beijing as the kernel research area. Shunyi District lies in the northeast suburb of Beijing, about 30 kilometers away from Beijing city. The whole district includes 12 towns, with 1,016 square kilometers land area and 550 thousands population. Shunyi District is situated to the south of Yan Mountain. The dominating landform is plain which takes up 95.7% of the whole area. Chaobai River, the first great river in east of Beijing, sinuously runs through all its area from north to south and provides abundant water resource. With warm and moderate climate, plentiful water and fertile soil, it's very suitable to develop plantation and becomes a big agricultural district in suburb of Beijing. The primary agricultural crop is winter-wheat, secondly is corn and a bit of rice fields

3. Data Source Used in Research

1) Remote Sensing Data

1. Imaging spectral data: 32 channels, the most primary data source in this research. This research mainly involves winter-wheat. So the imaging time was April 24, 1998, when winter-wheat was jointing and tasselling in this season. Except winter-wheat, there were also a few of spring-corn seedlings in the district, while rice seedlings hadn't been transplanted.
2. Aerial photos: the same time as that of imaging spectral data, these are infrared chromatic aerial photos with a scale of 1: 30,000 and a spatial resolution of 14 meters.
3. TM image: In order to compare with imaging spectral data, TM images of Apr. 20th, 1998 are collected, with a spatial resolution of 30 meters.
4. Spectral data of ground objects: Including synchronously surveyed spectral data of ground objects in the research area, such as wheat, water body, bare land and so on, as well as spectral data of wheat during each growing period and other vegetation types surveyed in research fields of Crop Institute Affiliated to Beijing Academy of Agricultural Sciences, with more than 100 spectral curves.

2) Non-Remote Sensing Data

1. Topographic map: with the scale of 1:50,000 and 1:100,000.
2. Digital elevation model (DEM): Get a contour map by digitizing topographic map with the scale of 1:50,000 and then generate the DEM.
3. Thematic map: Including land use map of 1995 with the scale of 1:10,000 and 1:50,000, soil fertility map (map of soil organic substance, nitrogenous fertilizer and phosphate fertilizer) and administrative boundary map etc.

4. Agricultural Crop Information Extraction

1) Multi-level Classification for Agricultural Crop Types

Image feature of ground objects in remote sensing image are very complicated. Generally, it's very hard to separate useless information away and extract useful information just by means of one method, especially for identifying different vegetation types. To solve this problem, this paper will extract agricultural crop information with multi-level classification method. Its basic idea is: based on spectral feature of ground objects in the image, we start with analyzing the separability of different ground objects on each wave band as well as their composite. Then we divide ground objects into several first level layers and each layer includes some ground object types. Following that we will take further steps to divide the first one into different second level layers, third level layers and so on. According to difficult degree of separating ground objects in each level and from easy to difficult, aiming at spectral feature of ground objects to be separated, we select different feature parameter and classification method, extract information level by level, make corresponding template and mask extracted image information to avoid the effect which will act on extraction of other ground object types. Thus the remainder types in the image become less and less and it becomes much easier to separate ground objects at next level. At last we will get the final result by adding the classification result of each level together.

The flow chart of multi-level classification method taken in the paper is shown as Fig. 1.

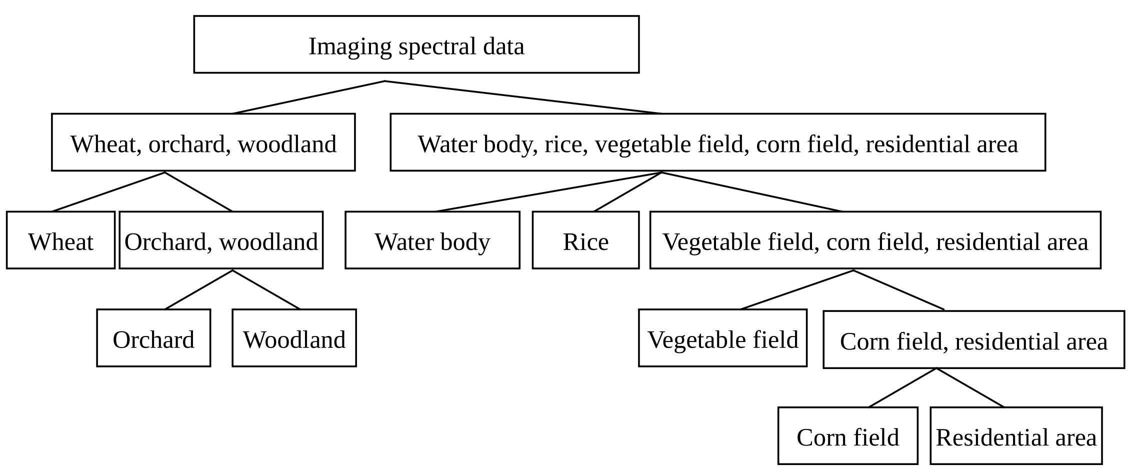

Fig. 1 Flow chart of multi-level classification

1. Separation of vegetation and non-vegetation

Firstly, to divide research area into two classes: vegetation and non-vegetation by means of NDVI. Fig. 2 is the original remote sensing image. Fig. 3 is the NDVI image. Fig. 4 shows the classification result of vegetation and non-vegetation. Compared with the original image (Fig. 2) we can directly find that the classification result of two classes is quite accurate.

Fig. 2 Original remote sensing image

Fig. 3 NDVI image

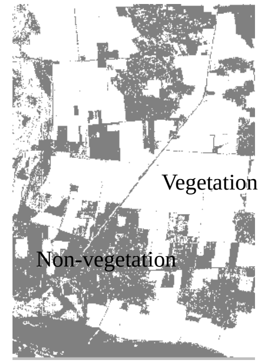

Fig. 4 Vegetation and non-vegetation sub-area image

2. Further classification of vegetations

a. Wheat extraction

Mask non-vegetation part first (Fig. 5), and then classify the image only including vegetations. The vegetation area includes three classes: wheat, orchard and woodland. By analyzing the dispersion of each class we can know that in the three classes the difference between wheat and the other two vegetation types is comparatively big, while the difference between orchard and woodland is comparatively small. So we separate wheat from the other two crop types first. Classification result is shown in Fig. 6.

Fig. 5 Image after masking non-vegetation

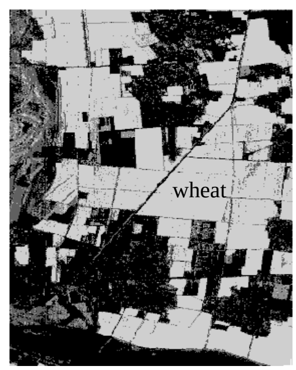

Fig. 6 Wheat information extraction

b. Separation of orchard and woodland

Make a template for wheat, take out wheat from all vegetation area by means of masking method and then make vegetation area leave ground objects of only two classes: orchard and woodland (Fig. 7). Spectral interference among different classes is decreasing along with the decreasing ground object classes,. It makes the classification easier and more accurate. As the small area and fragmentary distribution of orchard, it's not suitable to classify with maximum-likelihood method. Because that method based on statistics needs training samples with enough accuracy to get the right statistical parameters which are needed by classification, we adopt angle-matching method to separate orchard and woodland. Classification result is shown in Fig. 8.

3. Classification of non-vegetations

a. Water body extraction

Water body has special spectral features, so it's easy to be extracted from other classes. Select band 19, 20, 21 where the spectral difference between water body and other classes is maximal and then extract water body with the simplest minimum-distance method. The precision is up to 99.6%, only a little of mixture with marsh in residential area.

Fig. 7 Result after wheat masking

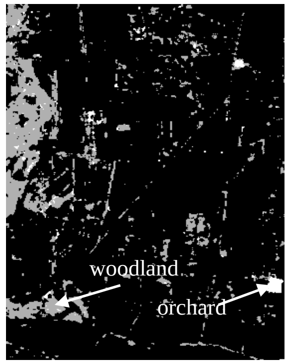

Fig. 8 Orchard, woodland classification image

b. Rice fields extraction

Usually rice fields are easily separated from dry-farming crops. But because rice seedlings haven’t been transplanted while imaging, there are neither vegetations nor water in rice fields. In this special case, its spectrum is quite similar to spring-corn field. Except for a few of differences in the first several bands of SWIR, there are very small differences among other bands, so it’s not easy enough to separate them correctly by their spectrum. By field-survey and discussion with experts from Shunyi Agriculture Bureau and Agriculture Science Institute we know that rice planting area in Shunyi is very small and the planting area and position haven’t been adjusted for many years, which means the spatial distribution hasn’t changed much for a long time. Accordingly, we make projection transformation for Shunyi District land use map of 1995, precise registration and overlay with imaging data, and then extract rice field by simple spatial operation.

c. Vegetable field extraction

The difference among Vegetable field, corn field and residential area is obviously more than that of corn and residential area, so we extract vegetable field first among the remainder three ground objects.

d. Corn field and residential area extraction

Being different from other classes, residential area is a composition combining with different classes such as building, road and so on. So its pixel-mixture phenomenon is serious and spectral composing is very complicated. The classification result with other methods is not good enough, so we take neural-network method to do it.

Hereto, all classification processes end. Stacking all classes extracted together in each level we get the final classification result map (Fig. 9), then by overlaying town-level administrative boundary to it and spatial operation of GIS we can get agricultural crops area statistical result of every towns in Shunyi District.

2) Classification Result and Discussion

The effect of classification method should be weighed by the accuracy of classification result. Each classification method by computer will give a report about classification precision after classifying. But this is only the spectral classification precision, not the actual one. Since factors such as same-object-different-spectrum, different-object-same-spectrum and so on, spectral classes are not one-by-one parallel to actual ground object classes. To verify classification result and evaluate classification method, we did fieldwork to check classification map by random sampling. The result of checking is satisfying and the classification precisions of every agricultural crops are all more than 95%.

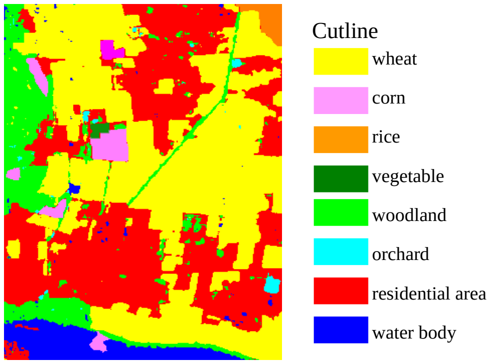

Fig. 9 Multi-level classification image

Multi-level classification method can adopt different classification methods at different levels when classifying an image. Different methods have different characters. We think that the absolute optimal method is not existent. For example, the neutral-network method has some advantages which are absent in some routine classification methods. In the meanwhile it also has some disadvantages such as difficulty in network construction, classification parameter selection and adjusting, too long time of training and so on. So we think we should do our best to select classification method with simple operation on condition that it can meet the requirements of classification precision. In the whole classification process, according to different requirements, this paper selected relatively simple methods such as minimum-distance method and maximum likelihood classification method, as well as relatively complicated angle-matching method and neutral-network method. The purpose is to make classification accurate as well as high efficient and practical.

5. Conclusion

Remote sensing image classification is the final purpose of remote sensing application. Different scholars advanced different methods from different viewpoints, different methods with different characteristics, but not being an ideal method. Multi-level method can synthetically make use of the characteristics of different methods. By dividing levels, it decomposes complicated remote sensing image classification process into relatively simple sub-processes. According to different classification objects, this method selects different feature parameters and different classification methods in different sub-processes in order to gain more effective classification results.

The key of multi-level method is to select the best feature parameters and effective classification method, extract information level by level and mask the information extracted at former level in turn to create conditions for extracting information at next level. While classifying, it doesn't need to extract information of only one class at each level and we could extract information of more than one class according to actual instance.

References

[1] Dai C.D. and Lei L.P., 1989. Spectral Information Characteristics and Optimal Waveband Combination of TM Image, Environmental Remote Sensing, Vol.4, No.4.

[2] Jiang X.G., Tang L.L. et al., 2004. Spectral Characteristics and Feature Selection of Hyperspectral Remote Sensing Data, INT.J. Remote Sensing, Vol.25, No.1.

[3] Jiang X.G., Wang C.Y. and Wang C., 2000.Spectral Information Characteristics and Optimal Wave band Selection of

Imaging Spectral Data，Arid Land Geography,Vol.23, No.4.