Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.

URBAN SENSING BY HYPERSPECTRAL DATA

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ABSTRACT:- The airborne hyperspectral imaging data has operationally been used in environment, geology, agriculture and other fields. In this paper, airborne hyperspectral data in visible, SWIR, MIR and TIR spectral region acquired by the 128 band Operational Modular Imaging Spectrometer (OMIS) was attempt in urban object identification. Natural grassland/artificial grasslands, and different types of metal slabs in construction roof have been successfully differentiated, respectively. Combined with Geographic Information System(GIS) technology, a large scale urban mapping by using airborne hyperspectral data was also discussed in this paper. The results suggest that hyperspectral imaging data, especially combined with short wave infrared and thermal infrared, has broad application perspectives in artificial object identification and urban investigation.

Key words: Hyperspectral, imaging, object identification, urban, investigation

INTRODUCTION

Recent advances in remote sensing have led the way for the development of hyperspectral sensors and the applications of the hyperspectral data. Hyperspectral remote sensing is a relatively new technology, which is currently being investigated by researchers and scientists with regard to the detection and identification of minerals, terrestrial vegetation, and man-made materials and backgrounds. The concept of hyperspectral remote sensing began in the mid-1980s and to this point has been used most widely by geologists for mineral mapping. Hyperspectral imaging sensor combines imaging and spectroscopy in a single system that often includes large data sets and requires new processing methods. Hyperspectral data sets are generally composed of about 100 to 200 or much more spectral bands with relatively narrow bandwidth (5-10 nm), whereas, multispectral data sets are usually composed of about 5 to 10 relative wider bands (70-400 nm). With the high spectral resolution, hyperspectral remote sensing has great application potential for analyzing complex urban scenes.

Because of the complexity of urban ecosystems, their spectral characteristics become more complicated. Affected by the human activities and natural power, the homogeneity of the urban surface goes worse. That makes remote sensing much difficult to classify the urban land using. Although the spectral characteristic of urban objects in visible and short infrared is not so clear, the hyperspectral data can exactly reflect the spectral features well. Hyperspectral remote sensing technology strengthens the sensors in discriminating spectral sorts, and it does good to the fine classification of urban landcover.

HYPERSPECTRAL IMAGING SYSTEM? ? OMIS

Operative Modular Imaging Spectrometer (OMIS) was recently developed by the Shanghai Institute of Technical Physics (SITP) of Chinese Academy of Sciences. As shown in table 1, OMIS has 128 bands. There are 64bands in visible/near infrared, 40 bands in short-wave infrared,8 bands in middle infrared and 8 bands in thermal infrared. Especially, from 0.4 to 1.1µm, its spectral resolution is 10nm, while from 2.0 to2.5µm, 15nm.. OMIS has the ability of acquiring the images of earth's surface in three continuous reflectance spectral regions and two emission spectral regions. The linear array detector with the optic-mechanical scanning system is adopted for OMIS. This imager is made up of five parts, which are optic-mechanical system, real-time calibration system, electronics system, real-time data recording and monitor system, GYRO stabilization plateform system and GPS orientation system. It can focus on the same pixel well in different band from visible to thermal infrared. It is proved that OMIS can be applied to the fields of geology, mineral resources, oil exploration, agriculture, forestry, marine resources, urban investigation and so on.

SPECTRAL CHARACTERIZATION OF URBAN OBJECTS

In this chapter, the spectral characteristics of major urban objects will be stated based on our recent researches. Hyperspectral image can perfectly reflects the spectral characteristics of the objects, [1] therefore it is the most powerful way for urban objects classification and identification. For different classes, there always are some different channels that will allow a particular class to be separated from other classes. Take vegetation for example, a unique spectral response within red to near infrared channels can be described by NDVI.

On the remote sensing image, we usually obtain information of the rooftop of constructions. It is important to focus our study on the spectral feature of the rooftop, which reflected by different kinds of building materials, such as bitumen, asphalt felt, concrete, different tiles with different colors and so on. From figure 1, the reflectance of white-doped rooftop is clearly higher than the most other urban objects. With the wavelength grows up, its reflectance constants as 80% and changes very peacefully. The reflectance of hoar asbestos has the same trends with that of white-doped rooftop. On the contrary, that of bitumen tile is relatively lower. Another case should to be pointed out is that both pitch and asphalt felt that are mixed with carpolite are higher than the pure one. We got some typical spectral curves of rooftops as shown in figure 1. Different types of rooftop materials can be discriminated by their spectral features. In visual bands region, the spectral curve reflects the color feature of the tile, as yellow tile and lark tile. When it comes to infrared, the curve exposed the difference of these two tiles.

The urban road is mainly classified as concrete and asphalt. In the suburb, there are a few roads paved by earth. Figure 2 describes the spectral curves of these kinds of roads? Concrete and cement roads have the highest reflectance and show an increasing trend. However, the reflectance of earth road is much lower, with 12% on 456nm and ascending very slowly to 35% on 850nm. Bituminous road has not such tendency in such spectral region. Also, there is a difference between bituminous highway and bituminous street because of the dust effect. The main reason is that the building time, the dust and maintenance conditions are difference.

As shown in figure 3, from 443nm to 668nm, the reflectance of sparse grassplot and lower thin crop is higher than that of hurst, well growing crop and clipped grassplot. This has a direct relation with the proportion of bared soil. On the other hand, from 734nm to 975.6nm, the clipped grassplot has the highest reflectance while the lower thin crop has the lowest one. The differentiation between different kinds of vegetation is much more clearly in the short wave infrared bands. So this region is the best wavelength to discriminate different vegetation.

Generally speaking, the reflectance of water is lower than any other objects in urban area. The average of the reflectance is about 3%, and at the infrared region about 0.75um, one of water goes to 0%. The more the suspending grain, the higher reflectance the water body. Both the size of grain and the concentration of pollutant also affect the reflectance. Usually, there is an inverse proportion between the reflectance and the purity of water.

The shadow is important to the environment of the urban because it can reduce the absorption of solar radiation. But it also envelops some urban objects. Those objects in the shadow can also reflect the radiation from dispersion. Because the objects in the shadow are various, the effect of the round objects is complex, and the shadow is multiplex, the spectral curves of different shadow-covered objects (such as vegetation) are different. So we can get the weak information from shadow and discriminate the objects in the shadow.

URBAN INVESTIGATION

Urban Objects Classification and Identification

With the great improvement of hyperspectral remote sensing technology, its application in urban areas has been expanded into many different fields. Urban objects classification or identification is the most important application aspect for hyperspectral data.

Many materials can be identified by unique absorption feature in their reflectance spectra such as minerals and vegetation. Due to the complication of urban scene and relative disorder of artificial object in city, it is not easy to get a satisfactory classification result only depending on pixel-to-pixel spectral analysis, especially when the materials lack strong absorption features or the remote sensing data has a relative low signal/noise ratio.[2]

We use hypers pectral data to detect the resource in Darwin city. In figure 4, the red areas are the places where the refrigerant gas leaks out and the power resources are chucked away. We use the infrared bands to trace the different thermal scene. As a result, we get this information to help Darwin city to rehab the constructions in which the attemperator system is not quite good.

Figure 5 shows that the coal and concrete surface both are classified well. It is obviouisly that all objects have different reflectance in different wavelength. According to this unhidden trait of objects, and with the assistance of a perfect spectral library, the power of discriminating objects by hyperspectral remote sensing will be strengthened greatly.

The most dramatic thing is shown in figure 6 and figure 7. In visible spectral region, two different signed grassplot in true color image of figure 6 almost have no difference. But after spectral analysis, we got distinct trait of these two areas. The comparison between their spectral curves with the spectral library shows that they are quite different. So we went to the pots to have a fieldwork and found that one is a true grassland and the other is an artificial grassland. While we focused on another place in the OMIS image shown in figure 7, we found that in visible bands the blue iron rooftop shows nothing different. But when we come to the infrared bands, an amazed thing happened: in one iron rooftop, there are three kinds of spectral curves. And after we checked the material of the rooftop, we know that the boss changed the material in economic reasons.

So, the hyperspectral remote sensing has unsurpassable advantages in object identification/classification and it has great potential in urban investigation.

Urban Mapping

In China, because of city booming, urban mapping is becoming significant. Urban mapping is to accurately describe the figure, structure, geography and relations with circumferences of the city. With the fast urbanization, urban mapping require a shorter cycle. As government confirms the urban planning, the city-planning department will publish the layouts of city in a very short period. So the data source should be refreshed in a short time. With the support of National High-Tech Plan 863 project, we have plotted the map of Zhongguancun landuse classification. As shown in figure 8, the land are classified into forty types, and in every land-using type, we had the field survey. After we got the data with pretreatment, we had it geometry and radiation corrected. With the spectral matches, we extracted different object information. Combined with GIS, we transformed the raster image into vector image, and mapped the thematic plot in the end.

Urban Geographic Information Systems (UGIS)

Based on hyperspectral remote sensing science and computer science, the development of GIS has provided a capacious field to urban planning departments. Technical aspects will not hobble the development of UGIS. One of the most factors that affect the UGIS is the refresh frequency of original surface data. Airborne hyperspectral remote sensing is the only way to meet the demand. Nowadays, China has stepped into the practical application stage. In urban planning management, to get timely and precise information of urban surface is pivotal step for the whole work. UGIS has the powerful function for data query, spatial analysis and synthesis management, but it should be assisted with hyperspectral remote sensing as the data source acquirer, importer and pretreater. With the development of "Digital Earth", UGIS will do more in urban planning and investigation.

CONCLUSION

The overall idea of this study is to show that hyperspectral remote sensing applied in urban area has immense potential. At the same time, it is still a tough task in relatively speaking. Hyperspectral remote sensing will not only be widely applied in the object identification and urban mapping, but also plays a key role in UGIS (Urban Geographic Information Systems) and Digital City.

ACKNOWLEDGMENTS

As a research program of the Laboratory of Remote Sensing Information Sciences, Chinese Academy of Sciences, this study is funded by the National Key Project of Science and Technology in 1996-2000, and supported by the joint research of IRSA, China. The development of hyperspectral remote sensing system applied in urban were studied based on the results of the projects of the National High-Tech Program of China.

REFERENCE

Ben-Dor.E, Levin.N., and Saaroni.H. , 1999,"Remote Sensing of an urban environment using hyperspectral technology.", Proceedings of the Thirteenth International Conference on Applied Geologic Remote Sensing,1-3 March,1999,Vancouver,BC,Canada, Vol. II:6-11.

Kruse, F. A., Careen-Young, K. S., and Boardman, J. W., Mineral mapping at Cuprite, Nevada with a 63 channel imaging spectrometer, Photogram. Eng. Remote Sens, 56:83-92, 1990

APPENDIX

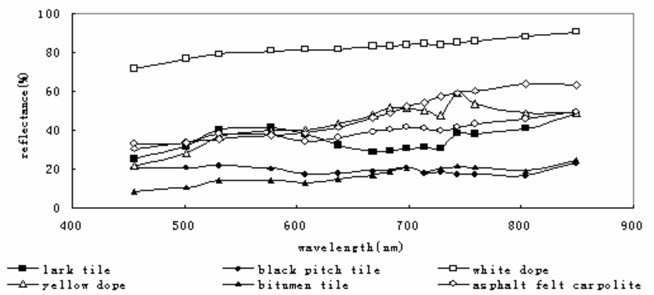

Figure 1: spectral curves of different materials of rooftops

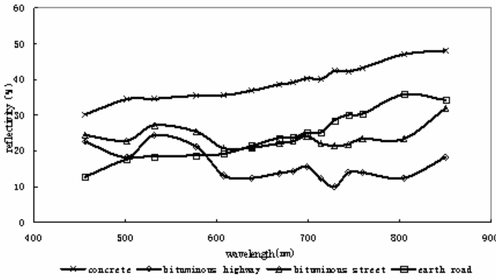

Figure 2: spectral curves of different roads

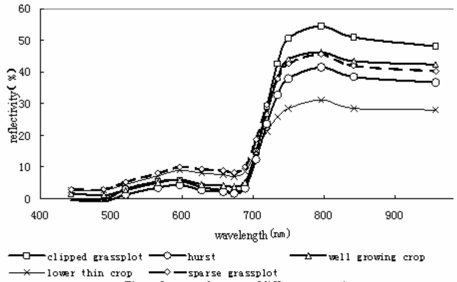

Figure 3: spectral curves of different vegetations

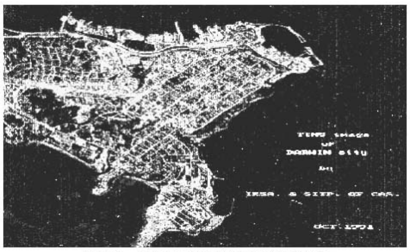

Figure 4 Hyperspectral application in Darwin City

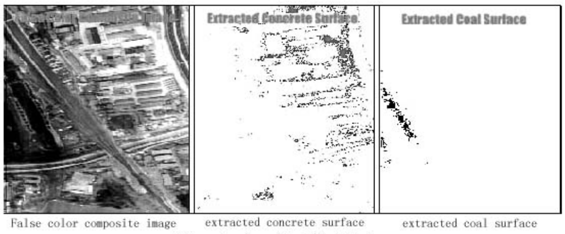

Figure 5: urban objects identification

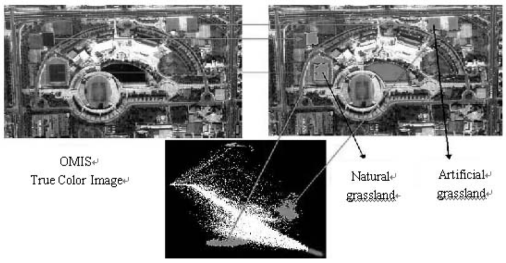

Figure 6: object identification: nature and artificial grasslands

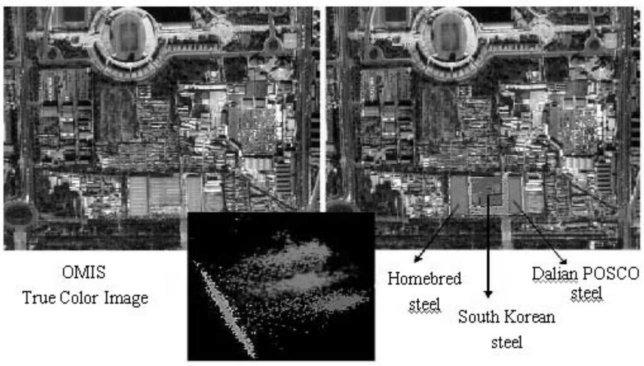

Figure 7: object identification: three types of steel

Figure 8: Map of land use classification of Yayuncun