THE KEY ROLES OF REMOTE SENSING TECHNIQUES FOR EVALUATING ENVIRONMENTAL ISSUES POSED BY MINING: A CASE STUDY

Yanhua Liu [a, *], Jinde Zhang [b]

[a] School of Information Science & Technology, Xiamen University, Xiamen 361005,CHINA, liuyh@xmu.edu.cn
[b] China Institute of Geo-Environment Monitoring, 20 Dahuisi Road, Beijing 100081, CHINA - zhangjd@mail.cigem.gov.cn

Commission VIII, WG VIII/12

ABSTRACT:

The tremendous need for mineral resources rooting from the rapid population growth and economical development in china has greatly accelerated exploitation of various minerals for last two decades, as a result, a broad array of environmental problems related to human mining activities, such as air and water pollution, land resources and inhabited environment devastation generated by land subsidence, and other hazards posed by landslide etc, increasingly puzzled us all, and furthermore, as the population and economy continue their rapid growth in the near future, pressures on the environment will still increase as well. Therefore, for continuously improving standard of people's living by means of maintaining rapid and harmonious economic development, a new economic development strategic plan to deal with the challenging dilemma between mineral resources and environment should be shaped and carried out according to present real environment status posed by human mining activities. Fortunately, the new innovation about remote sensing technology, especially the practical application of high resolution satellite photographs, has allowed us to capture, store, process and display an unprecedented amount of information about our environment rapidly and efficiently. In this paper, by a case study about a small region Northeast CHINA, we carefully investigate the key roles act by remote sensing techniques in evaluating environment issues related to human mining activities. Resumptively, these roles mainly exist in three distinct aspects: (a) by interpreting the satellite image, we can easily locate the sources of pollution and corresponding mines; (b) combining the quantitative techniques of remote sensing with fieldwork, we can accurately analysis and evaluate the environmental status of mining region; (c) rapid mapping about related environmental information and efficient data store and display platform. The good result illustrated in our paper will further strength our confidence in using the new remote sensing techniques to evaluate and monitor the environment related to human mining activities.

1. INTRODUCTION

With the rapid economical development and continuous population growth for nearly 30 years in CHINA, the environmental issues introduced by human mining activities are becoming increasingly serious and urgent for us to deal with. To completely tackle with these serious problems for achieving sustainable development, we present a three-step strategy. Firstly, we try to acquire precise information about the environmental issues by launching a geo-environmental surveying process. Then we can shape the detail repair scheme and corresponding investment plan base on present environmental status evaluated by quantitative data. Lastly, we begin to do the actual repair work and a long term monitoring work for retaining good environment in mining areas.

Just as the adage says seeking truth from facts, the basic environmental information is vital for evaluating, repairing and monitoring the environmental status of mining region. Therefore, the basic data about the environmental information should be collected in time to set up a database system for easily store and use. The synthesis of remote sensing technique and conventional field survey work is an effective approach to acquire such data.

In this paper, by a case study, we carefully investigate the important roles of high resolution satellite image and corresponding data processing software, and also point out the improvement for future use.

2. STUDY AREA AND DATA PROCESSING

This section describes the study area and how the raw data should be processed for extracting geological environmental information. The raw remote sensing data acquired from satellites usually contain many geometrical distortions, and these distortions should be corrected by a series of processing steps to get the final geocoded image which can be used to evaluate and monitor the geological environmental status about mining areas. Therefore, each step for processing the raw data is introduced briefly in this section.

2.1 Study Area

The study area, as illustrated in figure1, is located on Liaoyuan city, Northeast China, which is a very important industrial estate for China.

* Yanhua Liu. School of Information Science & Technology, Xiamen University, Xiamen 361005, CHINA, liuyh@xmu.edu.cn.
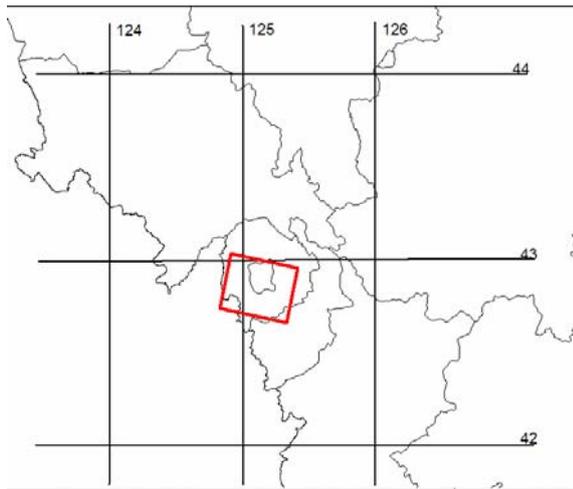
Figure 1 Study area

Initially done by Japanese at this area, the early work for appraising mineral resources can be dated back to 1911. Since 1949, large numbers of works about geological surveying for mineral reserves have also been developed widely. Of about 33 types of minerals already found, the only energy mineral is coal; the main metal minerals include iron, manganese, aurum, argentums and etc, the main non-metal minerals include limestone, marble, silicon and etc. Presently there are 266 mining company in all at this area, and the environmental pollution brought about by these mining company is becoming more and more serious.

2.2 Data Processing

The raw image data include a spot5 2.5m PA image and 3 spot5 10m XS images, can be transformed to a color geocoded ortho-image which can be used to extract the basic environmental data by two main processing steps: image fusion process and geocoding process.

The whole data process chain illustrated in figure2 can be easily implemented by ERDAS IMAGINE 8.5 remote sensing data process system. The original images are firstly enhanced by radiometric process module. And then, applying the RGB stack process module, 3 10m XS images are integrated to a 10m color image. Now we can begin our first main process steps to combine a 2.5m PA image and a 10m color XS image to a 2.5m color image. One of the key techniques for image fusion is to rectify the XS image according to the PA image, and at last, we execute a fusion algorithm named principle component analysis to complete this step.

GCPs and DEM are two pre-requisite inputs for image geocoding process. The GCPs can directly choose from 1:50000 relief map and DEM can generated by digitizing the contours in the same relief map. The DEM, illustrated in figure3 is also important information for evaluating geo-environment, because it is not only important controls for near surface water movement but also can influence regional climate.
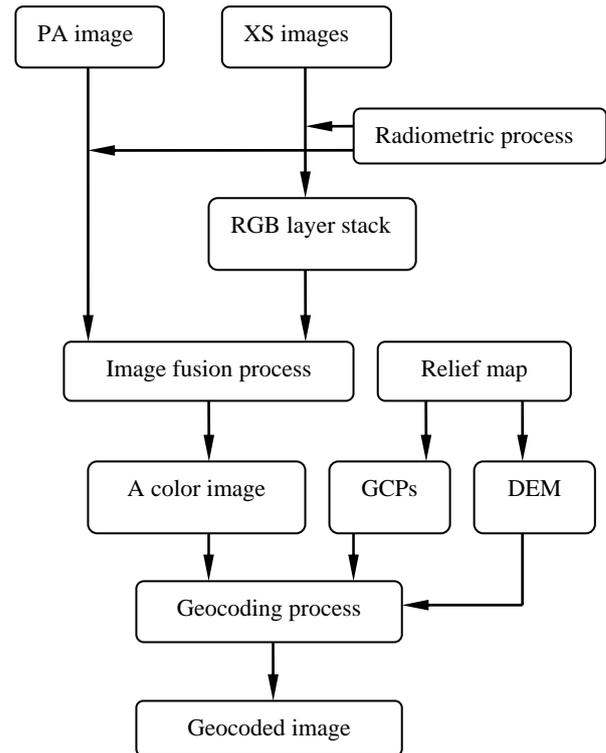

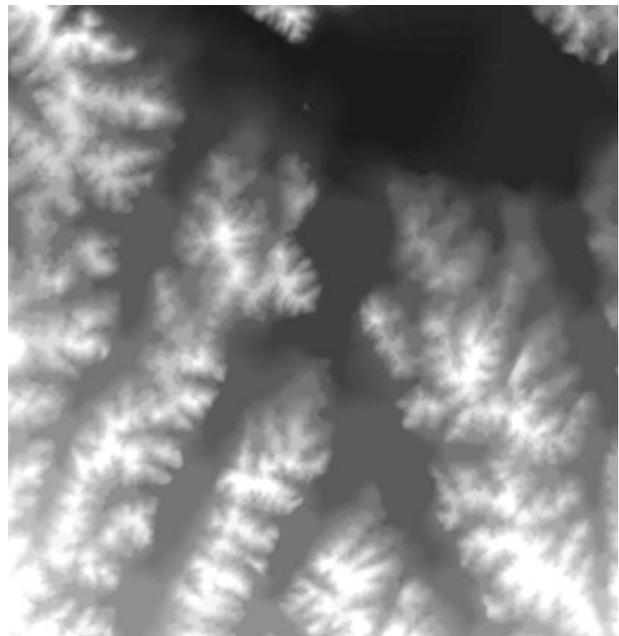Figure 2 Chain of data processing

Figure 3 DEM for study area

Geocoding is another important processing step. By this step, the geometry distortions of satellite image can be rectified to get final ortho-image, and each pixel of this orth-image can be related to its corresponding geography coordinates at the same time. A corrected polynomial algorithm taking into account complex terrain factors is chosen to do this processing step.
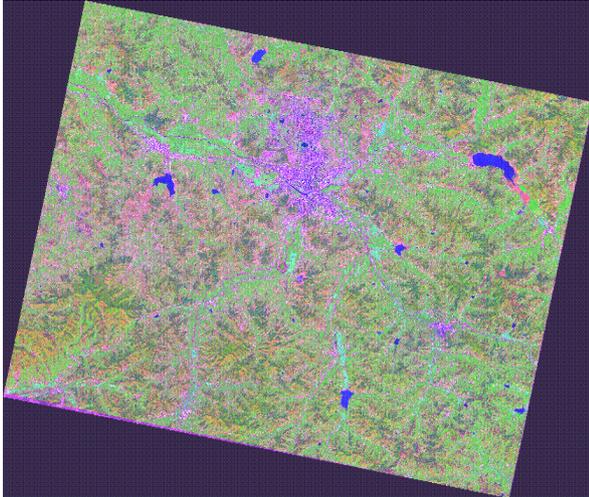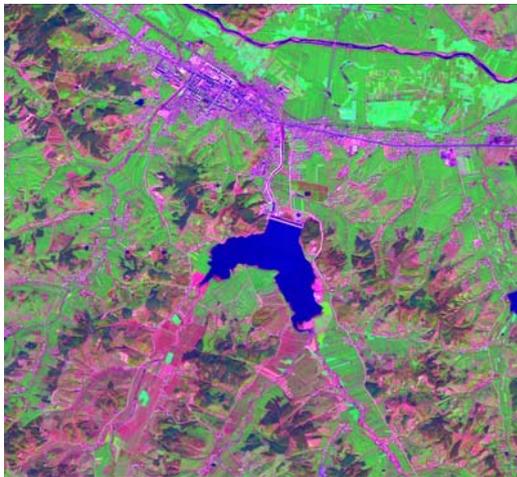
Figure 4 The geocoded image for study area

Figure 5 Part of geocoded image

The geocoded image of whole study area, as illustrated in figure4 and figure5 is our final processing result. And this image is also used as input data for extracting information about geological environment.

3. BASIC DATA FOR ENVIRONMENTAL EVALUATION

The ortho-image is still a raster data. To evaluate the environment of mining areas, we firstly should to extract the basic vector data from this raster data. All these vector data should be organized to different layers according to their attribution.

3.1 Update the Vector Data of Old Maps

Generally, we have the vector data of old maps at hand. These vector data including roads, water, vegetation, residential area, land cover and use, topography and etc, are very important for evaluating the environmental status of mining areas. However, they can not be used directly because the data are becoming out of data quickly with rapid economical development. Therefore,

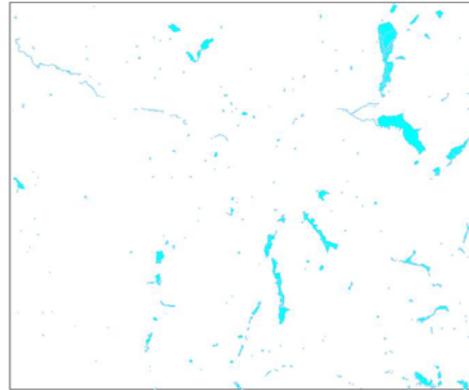these old vector data should be firstly updated according to new ortho-image.

Figure 6 Distribution of water with plane attribution

In fact, in order to keep the vector data consistent with the changed status of mining areas, we should update these data for a short interval. Presently, we formulate a complete workflow for this updating work, and some operators are employed to do this routine work technically. Of all these vector data, distribution of water is paramount important for our evaluation and survey work, because the possible serious effect brought about by mining activities is water pollution, and it can make the things even more bad that this pollution will spread quickly from one place to another place with water moving. Therefore, we should pay more attention to the pollution sources nearby water resources, especially the bigger water body with plane attribution illustrated in figure6.

3.2 Basic Data about Environmental Status Caused by Mining Activities

The basic data required for environmental appreciation about mining areas usually include the location of pollution sources and the areas influenced by these pollution resources. Some of these data can be directly acquired from the geocoded satellite image, but another data should be made certain by incorporated the satellite image and fieldwork.

Black color is an obvious characteristic of coal; therefore a great deal of pollution sources related to coal mining can be easily identified from the image. As illustrated in figure7, mine entrances for excavating coal is very clear in the satellite images. Coal piles illustrated in figure8 lay nearby the roads and buildings, can also directly located from the satellite images. In conclusion, surface pollution sources related to coal can be acquired by analysis the image at first hand.

Figure 7 Mine entrances for excavating coal

Figure 8 Coal piles lay nearby the roads and buildings

Some mines, coal or metal can be exploited by opencast working mode. And a very big pit such as in figure9 is finally left with mining activities end. This mining mode which also causes very serious geological environmental issues can destroy a great deal of precious black soil which is very important for agriculture. For metal mine, a pond for separating different minerals each other usually is a pollution resource, and this sort of pollution source is easily located by its black color.

Figure 9 Open pit and a pond for separating minerals each other

Limited by technique tools, there always have some basic data reflecting the geological environmental status caused by mining, such as landslide, land subsidence, ground fissure and etc, are very important but can not be directly extracted from the satellite image. At such a case, in order to acquire theses important data, fieldwork is necessary and the image can be used as an adjuvant tool at the same time. Concretely, the satellite image can be used as a tool to guide us to look for these pollution sources in fieldwork surveying; on the other hand, it also is a convenient tool to acquire the location information of these pollution sources.

4. MAIN FRAMEWORK OF DATA MANAGEMENT

Collecting the basic data is our first step to evaluate and monitor the geological environmental status of mining areas, and then, theses data should be analyzed to set up some models representing the geological environmental status. Therefore, a

three-layer framework illustrated in figure10 is formulated for further managing and analyzing these data concisely.

At the bottom layer, a software tool, such as ERDAS, ENVI and etc., is chosen to interpret the geocoded image and the fieldwork data. The acquired vector data are classified by different rules. One rule is the geometric characteristic of the data, such as point, line and plane, another ruler is the physical characteristic of the data, such as topography, surface water, land subsidence, and etc. all basic data are assigned to location information and loaded to a geo-spatial database system.
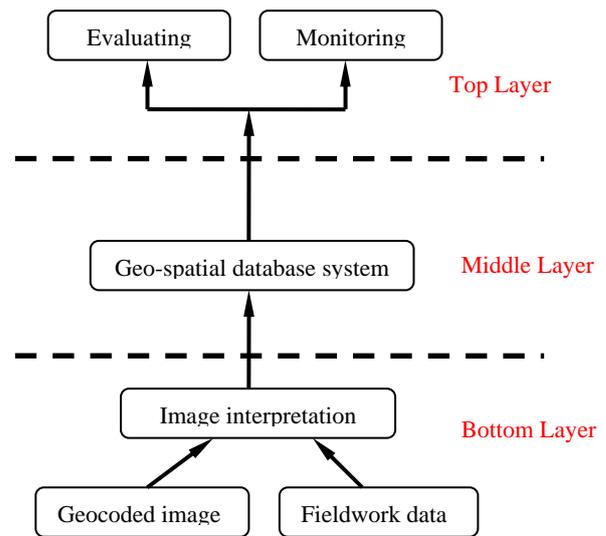

Figure 10 Main framework of data management

At the middle layer, a geo-spatial database system based GIS system is set up to store and manage the data. The GIS system, such as ArcGIS usually is a powerful tool for managing huge quantity of geo-data. All vector data coming from the bottom layer should be organized as different GIS layers according to their attribution and loaded to the geo-spatial database system. The geo-spatial database system is also equipped with development tools used to develop application module at the top layer.

There are two important modules at the top layer: evaluating module and monitoring module. In order to show environmental status of mining areas from different sides, these modules all present powerful tools for visualization and mapping. The evaluating module emphasizes particularly on modeling quantitatively to obtain an exact and all-around understanding about the geological environment for shaping a recovery scheme. While the monitoring module pay more attention to offer some variation information about some important parameters being sensitive to environment change so that the environment deterioration can be found and processed in time.

5. T CONCLUSIONS AND FUTURE WORK

With the rapid economical development and population growth, the contradiction between resources and environment is becoming more and more serious at mining areas CHINA. Therefore, in order to put forward a rational solution for developing the resources, it is an urgent task to evaluate and

monitor the geological environmental status of these areas. In this paper, an idea in which the remote sensing techniques play a very important role is introduced to cope with this task. In a word, the role played by remote sensing techniques can be summarized from three aspects. Firstly, the old vector data can be updated and some basic data about geological environment can be directly acquired from high accurate satellite images. Secondly, the satellite image can be used as an important tool in field work for geological environment surveying. And finally, all data can be assigned with geography coordinate and easily be loaded to a geo-spatial system equipped with powerful tools for data visualization, modeling and analysis.

The remote sensing images can undoubtedly provide valuable information about geological environment, and our final goal is to evaluate and monitor the geological environmental status about Chinese main large mines. Presently just an elementary scheme has been formed and a very small area is researched by this techniques, further work should be done to implement this goal in future work. Technique tools integrating multi-platform, multi-sources and multi-resolution remote sensing image, such as air photos, satellite images and even SAR images for extracting information accurately and effectively should be developed at our next step of work. Meanwhile, another important work is to construct accurate models for depicting the geological environmental status quantitatively so as to lay a foundation for educing a sound plan about resources development at main Chinese large mines.

REFERENCES

Zhang Jinde, Ren Ying, and Zhang Deqiang, Many Issues Discussion for the Work of Mines' Geo-Environment Harness in CHINA, Geo-Environment Protection and Geo-Hazard Prevention & Control (edited by Zhong Ziran and etc.), Chinese Dadi Press (in Chinese).

ERDAS IMAGINE Tour Guides, 2003 Leica Geosystems GIS and Mapping, LLC.