

STUDY ON THE KEY TECHNIQUES OF MINE ENVIRONMENT PROTECTION AND DISASTER PREVENTION DECISION SUPPORT SYSTEM (MEPDPDSS)

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ABSTRACT:

The Mine Environment Protection and Disaster Prevention Decision Support System (MEPDPDSS) will be discussed in this paper. In the proposed system, RS, GIS, GPS and their integrated technology can play important roles. This system consists of data capturing sub-system, data storage and management sub-system, data analyzing and processing sub-system, simulation and decision support sub-system, output and visual representation sub-system and graphic user interface (GUI). The main functions include: (1) collection and management of multi-source, multi-temporal, multi-scale and multi-resolution information, and (2) analysis and computation to typical and universal environment and disaster problems, and (3) analysis to specific environmental problems and disaster phenomena based on its feature, mechanism and mathematical and physical model and decision support for corresponding problems, and (4) dynamic simulation and visual representation of environmental and disaster, and (5) synthetic adjustment and regulation to regional resource, environment and disaster, further to regional sustainable development. This system can be developed by different strategies, and the most effective one is to apply rapid prototype method, in the future Component GIS will be adopted. Some issues are analyzed further, including the establishment of multi-source, multi-scale database, knowledge database, spatial analysis model and model library, visualization and the applications of Spatial Data Warehouse (SDW) and Data Mining (DM).

1. INTRODUCTION

Nowadays, mines are faced with a few serious environment and disaster problems. Because of some special and characterized properties of mine and mining production, those problems are characterized by complexity, synthesis, non-linear, uncertainty, and will limit the implementation of regional sustainable development. The environmental problems and disasters in mines are similar to ordinary region, but they are more serious because of excessive exploitation of mineral recourse, vast and accumulated solid, liquid and other waste or pollutants. The complex and nonlinear environmental problems and disaster in mines can be categorized to four types mainly: ground surface subsiding and soil degrading, water pollution and water environment degradation, solid waste pollution, air, sound and heat environmental pollution. Each problem has its own features and perhaps ground surface subsiding and soil degrading is the most serious. Especially it is the typical mixed phenomena of land resource wasting and destroying, ecological environment damaging and polluting and geological disasters such as land subsiding and collapsing.

How to protect environment and prevent and reduce disaster effectively is a key issue on regional sustainable development, especially how to use modern and advanced spatial information technology, including Remote Sensing (RS), Geographical Information System (GIS), Global Positioning System (GPS) and their integrated technology, is popular and perspective.

According to our studies in different mines and mining areas, it is both necessary and feasible to set up a Decision Support System for Mine Environment Protection and Disaster Prevention, or Mine Environment Protection and Disaster Prevention Decision Support System (MEPDPDSS) based on RS, GIS, GPS and other relative science and technology. In this paper, we would like to give some discussions to the key techniques of establish this system based on our experiments and practices in different mining areas such as Datong, Jinchen and Xuzhou mining areas in China.

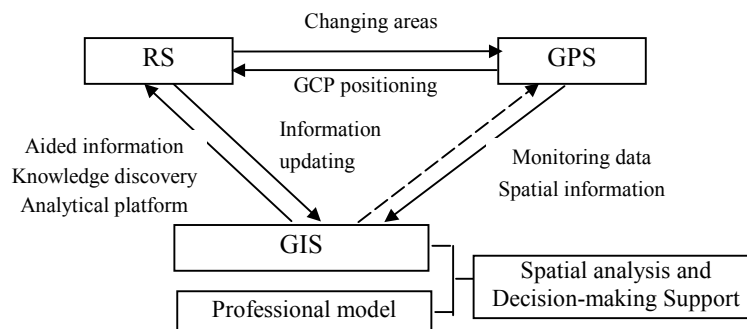


Figure1. The integration structure of RS, GIS and GPS

2. THE APPLICATIONS OF GIS, RS AND GPS TO SDSS

GIS, RS and GPS are very important in Spatial Decision Support System because of their advantages and capacities. In this proposed SDSS, RS can be used to identify and extract environment and ground disaster information synthetically and dynamically, and GPS can provide accurate spatial location information of certain entities or disaster area, and GIS can be used to manage and analyze all data and information and provide a primary platform for DSS. That is, this DSS is set up based on GIS. So many professional models should be developed in order to incorporate them into GIS. Especially, the dynamic monitoring scheme based on RS and GIS should be realized. Figure 1 is the integration structure of RS, GIS and GPS in this system, and Figure 2 is the SDSS based on Spatial Information Technology.

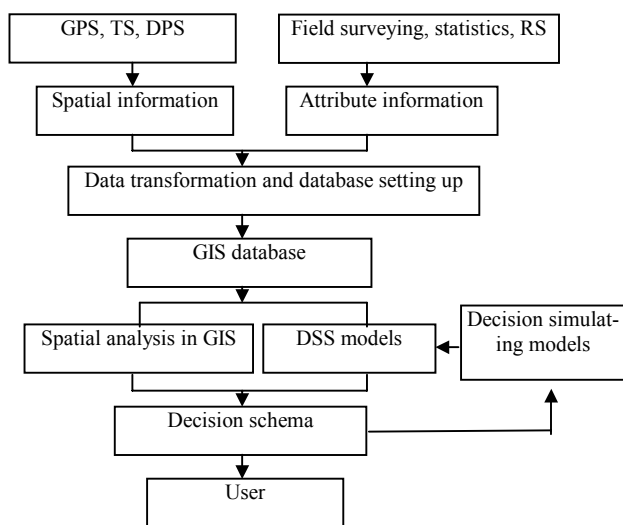


Figure 2. SDSS based on Spatial Information Technology.

3. THE FRAMEWORK OF MEPDPDSS

3.1 Composition

From universal opinion on information system, this system should consist of hardware, software, data and human, but for DSS, knowledge and model should be included, that is, this system includes six parts. Further this system consists of data capturing sub-system, data storage and management sub-system, data analyzing and processing sub-system, simulation and decision support sub-system, output and visual representation sub-system and graphic user interface (GUI). In order to keep up with the rapid development of distributed computation and network operation, the system should be established in local area network (LAN) environment. Figure 3 is the main components of the SDSS in addition to hardware, software and human.

3.2 Main Functions

The main functions of this system include:

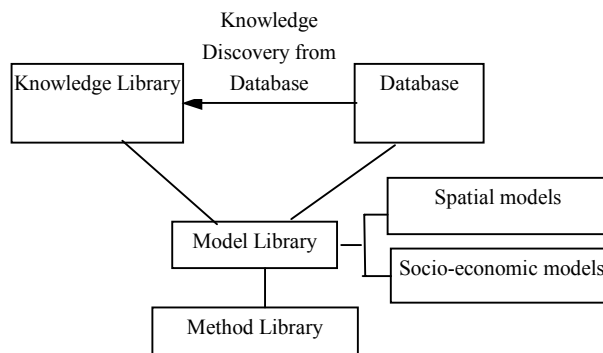


Figure 3. The main structure of this SDSS

(1) To collect and manage multi-source, multi-temporal, multi-scale and multi-resolution natural, environmental, socio-economic and disaster data and information according to certain standard.

(2) To analyze and compute typical and universal environment and disaster problems, mainly to environment impact assessment (EIA), pollution source analysis, environmental quality synthetic assessment, environment dynamic monitoring and evolving simulation both for individual environmental element and the whole environmental problems.

(3) To analyze specific environmental problems and disaster phenomena based on its feature, mechanism and mathematical and physical model and decision support for corresponding problems. That is core of this system, and different professional models should be included.

(4) The dynamic simulation and visual representation of environmental and disaster problems in order to provide direct and visual support to environmental treatment.

(5) The synthetic adjustment and regulation to resource, environment and disaster, further to regional sustainable development, and that is the ultimate goal of this system.

Figure 4 is the structure and functions of the MEPDPDSS used for DSS of land reclamation and ecology reconstruction in mining areas.

3.3 Development Strategy

This system can be developed by different strategies, and the most effective one is the rapid prototype method. In order to make full use of available data and system, this system should be based on a certain GIS software packages. Figure 5 is the development strategy used in this system

With the development and application of Component GIS (Com GIS), the main GIS function modules can be realized by related components, such as MapX, MapObjects, Titan Com GIS and so on. So we can develop some professional models by certain programming language according COM standards, and then integrate them with GIS components provided by GIS vendors in some common developing platform including Visual Basic, Visual C++, Delphi, Java and others. That is the most effective development strategy for SDSS and we will do more work on this technical route.

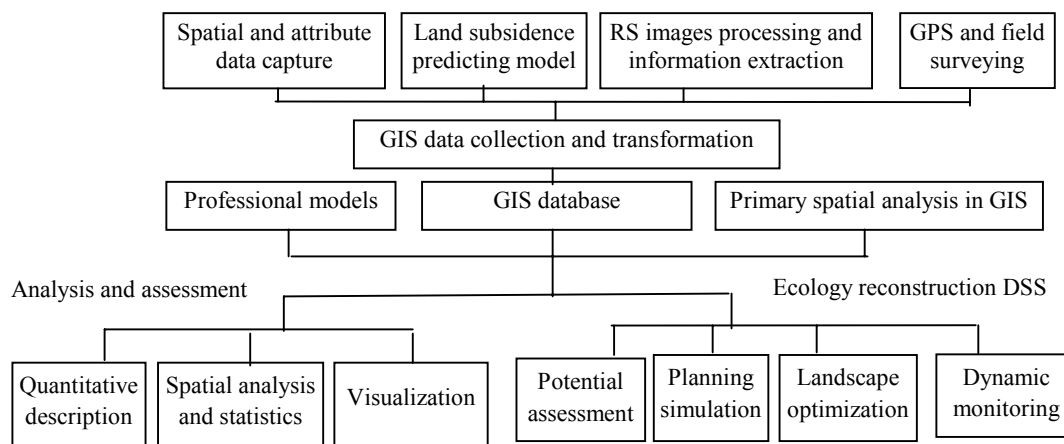


Figure 4. An example of MEPDPDSS used for DSS of Land reclamation and ecology reconstruction DSS based on RS, GIS and GPS

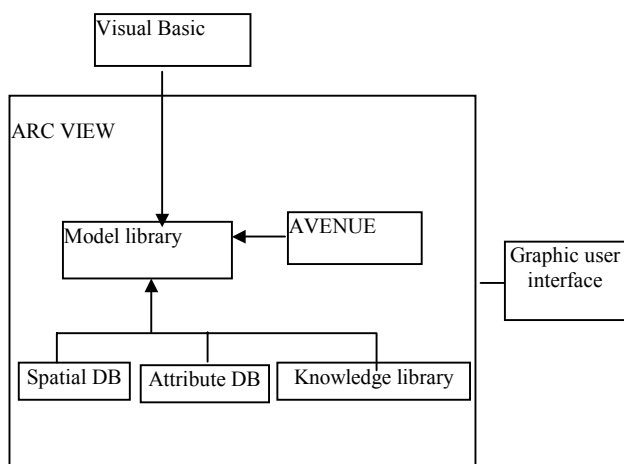


Figure 5. The development strategy of SDSS

4. FURTHER DISCUSSIONS

In order to build an advanced and effective SDSS, some key techniques should be solved, especially how to make full use of all available information and system, and apply modern computer technology. Here we would like to give further discussions to those issues.

4.1 Establishment of Database and Knowledge Library

The information in mining areas is very complex and various. They can be collected by different means including field surveying, investigation and statistics, prediction and estimation, and Remote Sensing imagery and others. In a word, multi-source information exists in mining areas. Furthermore, different scales are used to represent the ground and underground information, which is so called multi-scale information. So the multi-scale database should be built in order to make full use of all available data. In addition, all information about resource, environment and disaster is complex and various, so they must be managed and processed according to a certain rules and standards. Data standard and coding rules should be determined, and reasonable data model and database structure should be selected. Especially, metadata is important to maintain and use the database. Knowledge is

very important in SDSS, and it is the basis of analyzing and decision-making. In order to set up knowledge library, artificial intelligence (AI) and expert system (ES) should be taken into account, especially how to express knowledge and connect them with database and model library. With the development of Artificial Neural Network (ANN), SDSS based on ANN has got rapid progress. For example, it can be used to predict the occurrence of subsidence disaster.

4.2 Establishment of Professional Model Library

It is well known that all professional applications in GIS and DSS should be realized by professional models including mathematical, physical, experienced and supposed models. Because of a number of models involved in the SDSS, they should be organized and managed reasonably. Model library is used to do this task. Nowadays, professional models can be integrated with GIS, further with SDSS by four means, which are illustrated by Figure 6.

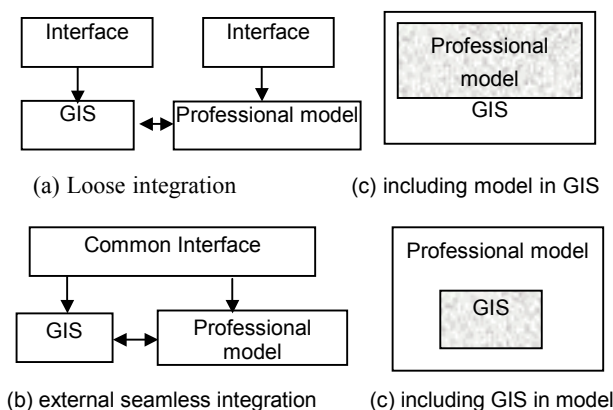


Figure 6. Integration of GIS with professional models

In order to program and develop those models, suitable methods should be selected. At present the main method is to develop the model by certain function and all functions are managed. In the future, development based on COM (Component Object Model) can be viewed as the most effective mean to develop professional models. But different protocols including COM/ActiveX of Microsoft, CORBA of SUN and Java Beans

are used now, so the selection of standard is very important. After all components are developed, component library can be built to manage all those models.

4.3 Visualization of Environment and Disaster

Visualization is the hot issue in different disciplines, and it is especially important and meaningful in environment and disaster domain. Visualization can provide users with direct, living and synthetic representation to typical phenomena and process, and it can be used to simulate and predict the trends of environment changing and disaster occurring. 3-Dimensional visualization is especially useful. Data model is very important to visualization and it is obvious that hybrid three-dimensional data model should be used. In the hybrid data models, raster, vector, DEM and CSG are combined according to the specific condition. In the future, Virtual Reality (VR) technology and Virtual Geographical Environment (VGE) may be the main developing direction.

4.4 Spatial Data Warehouse (SDW) and Data Mining (DM)

SDW is linked with decision-making support closely and is the hot issue in DSS community. In the SDSS, how to set up the SDW according to the practical demands should be considered in the future. SDW can overcome the shortages existed in conditional database. Furthermore, SDW will be the basis of SDM (Spatial Data Mining) and KDD (Knowledge Discovery in Database). By those new techniques the multi-source, multi-temporal and multi-scale information can be processed intelligently and automatically, and that will improve the quality and confidence of decision.

So the establishment and development of MEPDPDSS is a huge and complex engineering, and much work should be done further, especially advanced modern information technology should be used. We shall give more studies for other key issues and applications of new techniques in the future.

5. CONCLUSIONS AND PROSPECTS

From this paper we draw some useful conclusions on the establishment of Mine Environment Protection and Disaster Prevention Decision Support System (MEPDPDSS) as following:

(1) Complex and nonlinear environmental problems and disaster in mines can be categorized to four types mainly, that is, ground surface subsiding and soil degrading, water pollution and degradation of water environment, solid waste pollution, air, sound and heat environmental pollution. The SDSS can handle all those problems and provide a reasonable decision.

(2) It is both necessary and feasible to set up Mine Environment Protection and Disaster Prevention Decision Support System (MEPDPDSS) based on Spatial Information Technology whose core is RS, GIS, GPS and their integrated technology.

(3) This system should be set up based on GIS and make full use of modern advanced spatial information technology and some key techniques are discussed and effective solutions are provided.

(4) This system will play important roles to environment protection, disaster prevention and regional sustainable development.

But the establishment and operation of this system is complex and difficult. Here only some issues are discussed, and more work should be done further in order to improve this system and apply it to mines.

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