DATABASE MANAGEMENT AND IMPLEMENTATION FOR COAL FIRE DETECTION AND MONITORING IN THE RUJIGOU COALFIELD, NORTHWEST CHINA

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ABSTRACT

Coal fire monitoring by aerospace remote sensing and GIS techniques is an advanced approach, which has been implemented in the Rujigou coalfield, northwest China. A database of several different types of data, including remote sensing images, results of geological surveys, etc., has been collected and assembled in a PC-based information system, which is being developed by the International Institute for Aerospace Survey and Earth Sciences (ITC). This coal fire monitoring and management information system (CoalMan) comprises of two main parts: one is the database with its management tools, and the tools for data processing and analysis form the other. This paper first introduces the structure of the CoalMan information system, presents the data types and contents of CoalMan database, then shows the data management methods. A complex data analysis package is outlined too, as the core of the information system.

1. INTRODUCTION

Underground and surface coal fires manifest a serious problem in many coal producing countries. China is very rich in coal reserves, which are widely distributed across the country. Spontaneous and human-induced combustion occurs in a large number of the coal mining areas, so there are many coal fires spread over a vast area. With its advantage of large coverage, high spatial and temporal resolution, remote sensing is considered to be an appropriate technique to detect and monitor underground coal fires (Cassells, 1997; Prakash et al., 1997). In the framework of a joint project between the Netherlands and China, this method has been being implemented in the Rujigou area, Northwest China. In the first phase of the project data was collected from different sources (satellite images, airborne scanner images, aerial photographs, field temperature measurements, mining data, geological observations, topographical maps, etc.). Theoretical research was done for the modeling of coal fires, and the models were calibrated and verified during a joint fieldwork of the Dutch and the Chinese partners. For the implementation of the new technology an information system is being developed and implemented in the second phase of the project. The Coal Fire Monitoring and Management Information System (CoalMan) is being developed by the International Institute for Aerospace Survey and Earth Sciences (ITC), the Netherlands, with the cooperation of the project partners.

2. COAL FIRE MONITORING AND MANAGEMENT INFORMATION SYSTEM – COALMAN

CoalMan comprises of two major logical parts: the database with its management tools and the data processing and analysis tools. The focus of the discussion in the following is on the database, especially on the integration of the data, which have differences in data models, accuracy and resolution.

2.1. Data types and models

After analyzing the data sources and the user requirements, the following data types have been found useful and effective for the coal fire monitoring:

- Maps (both in raster and vector format).
- Digital elevation model (in raster format, representing the situation in the mines in the beginning of the project).
- Satellite images (optical, thermal and radar images).
- Airborne thermal infrared images and aerial photographs.
- Data of field measurements and observations.
- Reports, fire fighting and prevention plans.
- Field photos.

Coal fires are typically 3D phenomena, which can be the best represented with 3D data models (e.g. voxels). In reality, developing a full three-dimensional database is very expensive and time consuming, so in several cases practical limitations do not allow the use of this complex approach. In other cases, if the applied modeling techniques allow the projection of the processes onto a plane, it is more practical to use the simpler 2D data structures. This is the case of CoalMan, where the geological setting is described with the help of 2D data models: raster elevation models of the coal seams and interburdens and sections generated from the elevation models.

2.2. CoalMan structure

The Integrated Land and Water Information System (ILWIS), product of ITC is the supporting GIS software in CoalMan (Figure 1). From the CoalMan interface, written in Visual Basic, ILWIS functions are invoked by DDE (Dynamic Data Exchange) calls. Map and image data are stored in ILWIS format, whilst a large number of tabular data are stored in a separate MS Access database

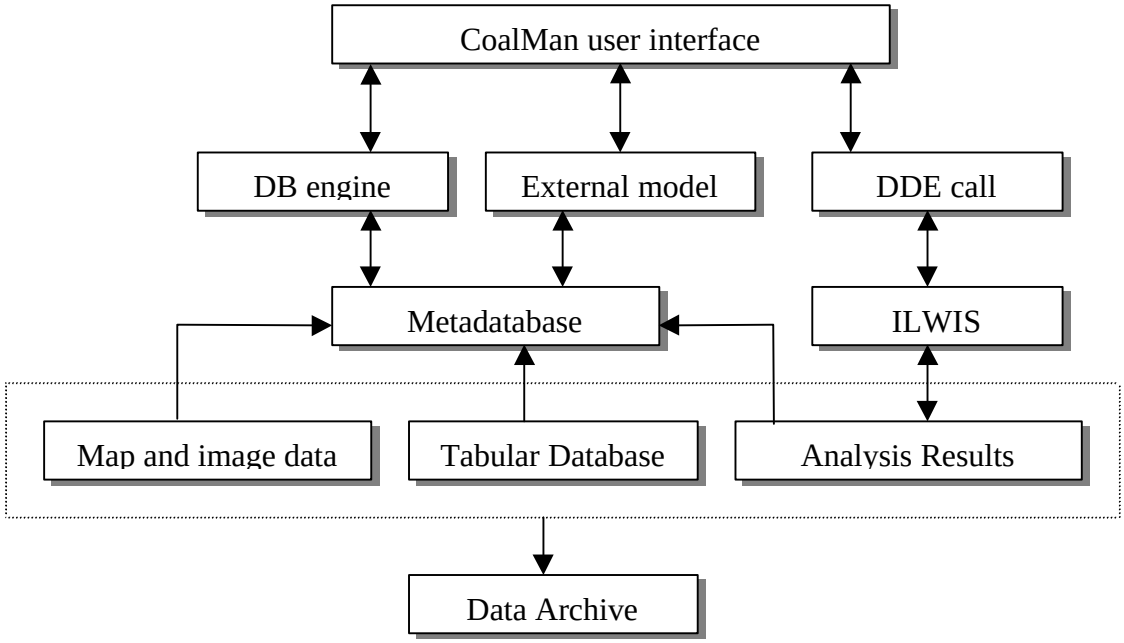

Figure 1. Structure of CoalMan information system

To maintain the database, CoalMan uses a metadatabase, which contains information about the location of the data (images, maps and tables) as well as history and other additional information related to the data objects.

3. DATABASE MANAGEMENT IN COALMAN

CoalMan is designed to provide better database management functions than the ones available in the underlying GIS. The database of CoalMan is constructed of a complex system of folders and subfolders. A metadatabase provides easy access to any of the available data, providing selection criteria according to their thematic content regardless to their location.

3.1. Metadata

Metadata is "data about data", i.e. the background information, which describes the location, content, quality, condition, and other appropriate characteristics of the data. The main uses of metadata in CoalMan are:

- data documentation,
- data browsing and
- data transfer.

The purpose of metadata of CoalMan is to provide a interface between user and digital spatial data, to help users find the data they need for their intended application and to insure that potential data users can make a decision about whether data are appropriate for the intended use.

3.2. Integrity Check

All the applications (tools) approach the database via the metadatabase. Therefore, it is important to maintain the integrity of the database, i.e. to have all the objects, which are stored in the database, registered in the metadatabase.

Integrity check is done automatically by CoalMan: it compares the information stored in the metadatabase with the actually available data. In case of discrepancy, CoalMan sends a warning to the user and starts the metadata management functions. The user can decide to delete the registration of the actually lost data from the metadatabase. If new data are found by the integrity checking programme then the user can register this data into the metadatabase.

3.3. Metadata applications: data entering, browsing and processing

Tabular data are stored in MS Access tables, which are transformed into ILWIS format if map-related operations (e.g. interpolation, map display) are requested by the user. The

CoalMan interface contains forms for entering these data (e.g. coal seam elevations).

Map data are entered into the database by storing them in one of the folders of the database. The integrity check tool is then used to locate automatically the data objects and to enter the additional information into the metadatabase.

To browse the database, CoalMan provides several forms based on the Structured Query Language (SQL). Information about satellite images, aerial photos, DEM, maps etc. can be browsed via the metadatabase. When the user selects a data object it is displayed or transferred to a special application, for example to the coal fire detection tool.

The analysis is done either by special tools developed as independent executable programmes, or by series of ILWIS operations. Although the full functionality of ILWIS is available for the user behind CoalMan, the proper use of them needs special knowledge about GIS and image processing. Therefore, some complex coal fire related procedures are built in CoalMan. If the user invokes any of these procedures the user interface by sends a series of DDE calls to ILWIS. An example for this is the display of a selected geological section.

3.4. Bilingual support

For the convenience of the Chinese users the CoalMan software provides two language versions: English and Chinese. The multilingual support is implemented as a look-up table in the database. The data structure of it is shown in figure 2. It is in fact a multi-dimensional string array, from which those strings are loaded which belong to the selected language.

String ID	Chinese ID	Chinese string
	English ID	English string

Figure 2. Data string structure

CONCLUSION

In May, 1999, a test version of the CoalMan software was installed and tested in the Rugigou coalfield, Northwest China. The users approved the data structure, including the handling of geological data with the 2D data model.

The role of the metadatabase was proved to be important. The data set of the remote sensing images is planned to grow quickly during the operational monitoring of the coal fires. The implemented data structure and database integrity tools provide flexibility to add new data sets without size limitation imposed by the software.

ACKNOWLEDGEMENTS

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