

Conceiving and design of coalfield fire area dynamic monitoring system in China

Kang Gaofeng Wang Xiaopeng

(Remote Sensing Application Institute of Aerophotogrammetry &
Remote Sensing of China Coal, Xi'an 710054)

Abstract: According to the guiding idea of “ digital fire area “ stratagem, with GIS working method transpierced in overall process of system construction, the coalfield fire area monitoring system based on network, which is advanced in technology, perfect in performance, highly efficient in operation, is established by full means of computer technology, “ 3S “ technology and network technique so that coalfield fire area monitoring data from collection, transmission, disposal, processing to model analysis forms a full data service architecture, which provides a platform for fire area dynamic monitoring and evaluating analyses and an aid decision making support for coalfield fire area governing. coalfield fire area dynamic monitoring system is established by carrying out collation and input for history data and actuality data of coalfield fire area. It can realize management, show, query, output of monitoring information and form coalfield fire area monitoring data from collection, transmission, disposal and processing to a perfection data service system of model analysis, furnish a platform for fire area dynamic monitoring and evaluation analyses and an aid decision making support for coalfield fire area governing.

Keyword: coalfield fire area, coal fire monitoring, dynamic monitoring system

0 Introduction

Along with the strategy implementation of west large development, coalfield fire also impacts the society, economy development and humanity living environment quality from multi-level and multi-path and is developing to become one of graveness disasters involved in resource, environment, economy and population problems. Our country region is of expansion, with full coal resource, but spontaneous combustion of coal is fully severe and coalfield fire areas are fully of up growth. Thus coalfield fire area dynamic monitoring system is built by using modern information technology, especially aeroastro-remote sensing technique, GPS and GIS technology to ascertain coalfield fire area actuality; to penetrate the burning orderliness, to forecast the coalfield development trend, to analyze and evaluate the environmental effect, to raise the governing measure and to authenticate the fire extinction effect, which is a demand of enhancing the decision gist of coalfield fire extinction working and also expediting fire extinction schedule.

1 Current coalfield fire area monitoring actuality and existent main problems

Since 1960s of the 20th century, our country has conducted the survey and governing for north coalfield fire areas and accumulated the abundant coalfield fire area information in the recent 40 years. But information of various phases, various fire areas are of great varieties and anfractuosity. No longer have traditional methods facilitated the memory management of great capacity information. Meanwhile, due to lack of centralized management, these information resources are not high in integration and use degree, not good in real-time feature and difficult to share data, which has no means of exerting a momentous action and has also difficulty to provide

the timely, overall and creditable gists for leader.

Monitoring method and means of current coalfield fire area are geophysical prospecting, gas analysis, site thermometry, field investigation and others, which exists the problems in that monitoring cycle is long, cost is high, monitoring results only represent and reflect partial fire area situation and model is imperfect and others. It can not reflect the fire area change dynamically, cannot carry out a comprehensive analysis for various fire areas monitoring data and cannot consider coal fire igniting orderliness, development trend and burning rate and others from overall situation. It is not very perfect in the aid decision making model of coal fire environment impact appraisal and coal loss quantity and others, which can not enhance scientificness and rationality of decision-making.

2 Establishment of coal fire monitoring system

By establishing a three-layer monitoring system of spaceflight, ground and underground, it can ascertain the coalfield fire area scope, intensity, depth, coal loss and other coal seam spontaneous combustion element temporal and spatial variations, furnish basic data for coalfield fire area dynamic monitoring system and furnish the gist for executive plan of fire extinction engineering and effect appraisal of coalfield fire area governing. Adoptive monitoring technology means are as follows:

2.1 Remote sensing monitoring

It first ascertains a remote sensing dynamic monitoring index system of coalfield fire area by analyzing indicative feature on ground, formed by coalfield fire area. By using ETM+, MODIS, ASTER and other different period of aerospace remote sensing information source, combined with infrared temperature measurement and other ground remote sensing exploration as well as global positioning system (GPS), it ascertains distributional characteristics of various monitoring indices of coalfield fire area. By comprehensive analysis, it ascertains coalfield fire area scope and intensity of different period/times and different regions and ascertains keystone monitoring fire area.

2.2 Geophysical prospecting monitoring

By using the magnetic method, electrical method and other geophysical prospecting means as well as a field investigation and other methods, it ascertains self-combustion zone boundary for remote sensing monitoring key fire area. Combined with the verified method by drill, it carries out the fire area monitoring and furnishes basic data for executive plan of fire extinction engineering and effect appraisal of coalfield fire area governing. adoptable methods are as follows:

A. High density electrical method

According to terrane resistivity change before and after burning, burning area boundary is reconnoitered.

B. High precision magnetic method

The method relies on the thermoremanence theory and high temperature's impact for magnetism to observe magnetic variation within fire area and determines coal layer burning depth and describes coal layer flaming development trend. Thermoremanence scale depends upon the change situation of fire area temperature.

C. Natural electric field method

Natural electric field method relies on natural electric field theory to observe natural electric field change within fire area. Coal burning process would cause coal layer and a series of physical and chemical change in ambience, whose change scope is related to temperature and the higher the temperature, the larger the electric field intensity.

D. Electromagnetic method

Because stratum would generate electromagnetic effect under stimulation of outside alternating electric field, it can detect its existent possibility via different electromagnetic effects before, during and after coal layer burning with two methods of MT and CASMT.

E. Physical properties measure of the rocks

Survey work of physical properties of the rocks primarily furnishes basic data for geophysical prospecting explanation. Physical property measure of the project includes rock resistivity and susceptibility and other parameters of top-plate and soleplate of coal layer before and after burning.

2.3 Geochemical exploration monitoring

Chemical exploration is a method to carry out geologic exploration by measuring and analyzing some kind of physical content change in surface soil layer. In flaming process of coal layer, there is a great deal of volatility ingredient effusive to ground surface. These substance content in surface soil have a bigger relativity to coal fire. Coal fire detection can adopt two methods of radon gas measure and hydrocarbon (gasses) measure.

2.4 Boring monitoring

Regular monitoring method of fire area drill includes boring temperature method and boring eudiometry. Boring temperature method uses thermal resistance and digital thermometer to measure temperature, records boring temperature termly according to depth gradient interval, analyzes change orderliness of temperature in boring and ascertain temperature anomaly situation of fire area according to mean value of maximum temperature in boring.

Boring eudiometry monitoring gasses include CO₂、CO、O₂、H₂、CH₄、N₂. By carrying out sample analyses termly for characteristic gasses of these fire area and comparing mean value of a variety of gasses in monitoring overall process with reference hole, it final evaluates burning situation of regional extent controlled by various borings.

3 The objective of the coalfield fire area dynamic monitoring system

According to the guiding idea of “digital fire area“ stratagem, with GIS working method transpierced in overall process of system construction, the coalfield fire area monitoring system based on network, which is advanced in technology, perfect in performance, highly efficient in operation, is established by full means of computer technology, “3S“ technology and network technique so that coalfield fire area monitoring data from collection, transmission, disposal, processing to model analysis forms a full data service architecture, which provides a platform for fire area dynamic monitoring and evaluating analyses and an aid decision making support for coalfield

fire area governing.

4 System structure design

According to assignment and function of coalfield fire area monitoring coalfield fire area dynamic monitoring system is divided into fire area information management module, fire area analytical calculation module, fire extinction planning and design module, environmental impact assessment module and multimedia demonstration module (Fig. 1). According to implementation content, implementation method and user's demand, these module can adopt client/server (C/S) or browser/server (B/S) architecture.

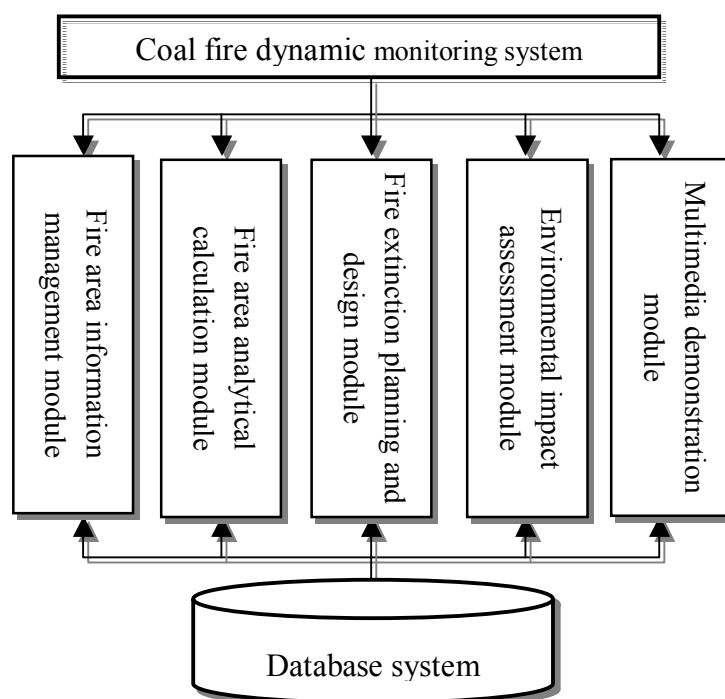


Fig. 1 system integral frame

A. Fire area information management

It mostly implement client functions of input, edit, modification, browse, analyses, thematic drawing of coalfield fire area dynamic monitoring system data as well as server functions of data backup, recovery, security management, metadata management and so on.

B. Fire area analytical calculation

On the basis of history data analyses for coalfield fire area monitoring, it establishes a variety of analyze evaluation model, mainly including burning depth and velocity analysis model, burning trend analysis model, coal resource loss quantity analytical model and others, thoroughly excavates applications potential of dynamic monitoring data and furnishes aid decision making information for coalfield fire area governing.

C. Fire extinction planning and design

By analyzing current coalfield fire area burning trend as well as strength range change, it plans governing grade, calculates main construction quantity as well as ancillary

works quantity of main construction quantity and design fire extinction engineering drawing.

D. Environmental impact assessment

Surrounding environmental influence scope and degree is appraised by research for heat quantity, a variety of toxic and noxious gas liberative by spontaneous combustion of coalfield fire area so as to establish an evaluation model of coalfield fire for environmental effect.

E. Multimedia demonstration

With text, graph, image, chart, photo, cartoon, sound, video and other manifold manifestation form, it carry out visualized and vivid display for coal fire information and damage, fire extinction governing working and others, and propagandize harmfulness of coalfield fire area and governing outcome of coalfield fire extinction to cause public's recognition for coal fire and coal fire governing.

According to national standard and industry standards, combined with special requirement of coal fire dynamic monitoring, it determines data code system, system construction codes and standards, quality control and process management specifications and others. It furnishes uniform standard for various data to construct database and establishes basic geography, remote sensing, geophysical prospecting, gas analysis, field thermometry, field investigation and other special topic data management systems (Fig. 2) on the basis of dynamically monitoring data collection. Under the requirement of database uniform standard and specification, it carry out data integration and collation. Based on various digitized landform map and thematic map, it establishes data management system of coalfield fire area and establishes data management maintenance system based on GIS platform.

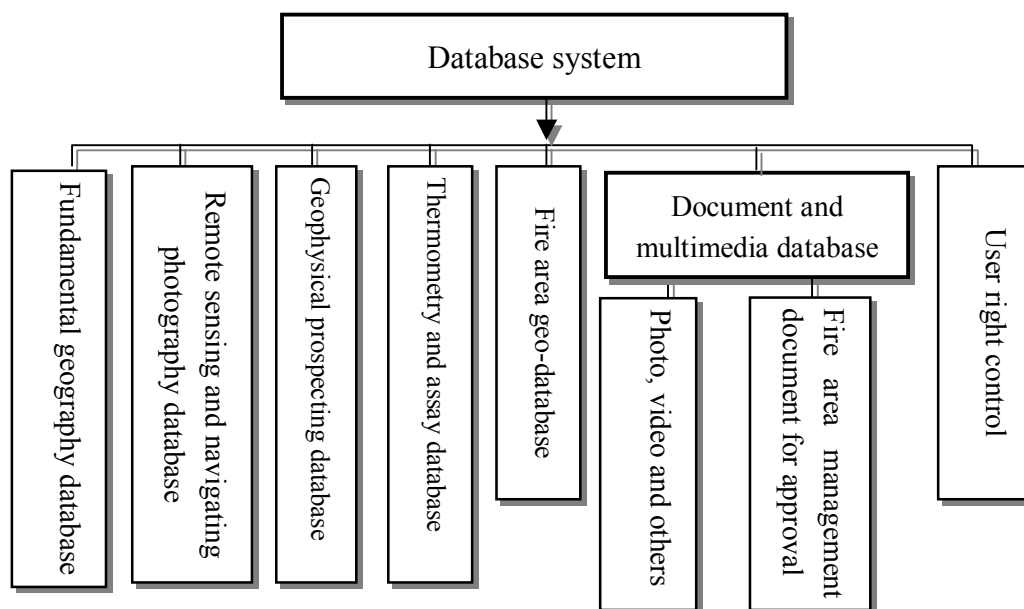


Fig. 2 data base architecture

Starting from physical shape and source of the data of data required, according to data content and database type, it unfolds construction of meta-database. By means of database management tool and advanced space model, algorithm and spatial analysis

function, it develops out data conversion, disposal, analyze and maintenance tool used in coalfield fire area dynamic monitoring, furnish base data document of strong exactness, conformity and present situation feature for professional analytic system.

5 System function

By establishing coalfield fire area dynamic monitoring system, it can realize the following functions :

- A. By termly remote sensing monitoring, it can monitor burning change situation of various coalfield fire area and discover new fire point and afterburning fire point.
- B. By monitoring and detecting new fire point or key fire area, it can have monitoring data of work area input into system with the fastest speed to participate in model calculation and generate thematic map of strong real-time feature for the aid decision making.
- C. Via model analysis, it can carry out dynamic understanding for burning trend of coalfield fire area.
- D. According to dynamic monitoring data, it can evaluate coalfield loss quantity caused by coalfield fire area burning.
- E. Appraising impact status of current fire area burning situation for ecology environment.
- F. According as dynamic variation and development trend of current coalfield fire area, it carries out planning and decision-making of fire extinction.
- G. It supervises executive situation of fire extinction program of coalfield fire area, carries out the next fire extinction planning and design and estimates fire extinction construction quantities of fire extinction region.
- H. It propagandizes harmfulness of coalfield fire area and outcome of coalfield fire extinction governing, communicates and exchanges with outside.

6 Epilogue

By establishing coalfield fire area dynamic monitoring system, it can realize informatization and numeralization of coal fire monitoring and governing. It is the demand of enhancing science and technology content of coalfield fire extinction and achieving goal construction of “digital fire area” and will certainly play an important role in the future work.

Reference :

- Investigation of coal fire in Ningxia Rujigou with aerospace remote sensing method. 1989. geologic remote sensing center of Ministry of Geology and Mineral Resources.
- Exploration report of Ningxia Rujigou coal spontaneous combustion, 1995. Beijing remote sensing company.
- Joint Research Report of BRSC and ITC, 1997. Manual of coal fire detection and monitoring.
- Research report of China Ningxia Rujigou coalfield fire area environmental monitoring and governing by Beijing remote sensing Company, 1997. Sino-Holland joint study project.
- Guan Haiyan and others, 1998. Survey and research for China north coalfield

spontaneous combustion environment, coal industry publishing house.
Zhang Xiangmin, 1998. *Coal Fires in Northwest China*, doctoral thesis, ITC.
Monitoring report of Ningxia Rujigou coalfield fire area remote sensing, 2001.
Remote sensing application institute of aerophotogrammetry & remote sensing of China
coal.