CHEMICAL ENGINEERING TRANSACTIONS

VOL. 51, 2016

A publication of AIDIC

The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Tichun Wang, Hongyang Zhang, Lei Tian

ISBN 978-88-95608-43-3; **ISSN** 2283-9216

DOI: 10.3303/CET1651171

Research and Application of the 3D Comprehensive Integrated Mine Management System

Ping Wang

School of Safety Engineering, China University of Mining And Technology, Xuzhou,Jiangsu221116,China
wpjob2005@126.com

The paper discussed the design objectives and implementation technique of the comprehensive integrated mine management system based on integration and the 3D comprehensive integrated technology. The paper chose Babao Mine as a practical case to analyze its application conditions and effects. As a management information system, it combined graphic data management, attribute data management and spatial data analysis together. With a combination of security monitoring, personnel position, roof pressure monitoring, video monitoring and the automatic control system, the system realized such functions as 3D visualization, comprehensive integration and alarm linkage of the mine, thus significantly improving the mine production schedule, security monitoring and emergency rescue efficiency.

1. Introduction

Currently, itis inevitable to use informatization to promote coal industrialization, to develop new industrialization and to construct new-type modern mine if coal enterprises intend to upgrade mine security assurance, realize high output and high efficiency, and strengthen core competition(Chen, 2007). It is also an important roadmap to develop the coal industry with science and technology(Démeh and Rosengren, 2015). Coal enterprises are gradually promoting comprehensively automatic and informationized mine management, as well as advancing the intelligence process of mine. In general, there are some problems in various systems of mine inspection and monitoring as well as in construction of the system of production automation. For example, information in interdependent systems is isolated from each other, thus failing to realize alarm linkage; the format of base maps in the monitoring system are basically image or flash(Liu et.al, 2015). Complicated and difficult maintenance of them leads to shortened service life of the system and causes the system less practical; most of the systems fail to realize 3D visualization or 2D & 3D integration(Kwakkel and Auping, 2013)(Wang and Yang, 2014), therefore the display is not intuitive and difficult to update; the 3D integration program is as expensive as to cost tens of millions of Yuan. To address the above issues, it is of great practical meaning to research and optimize the 3D comprehensive integrated mine management system.

2. The objective and features of the system

2.1 The objective of the system

Aimed at application of mine scheduling, and based on the 3D mining engineering map, the system combined security monitoring, personnel position, roof pressure monitoring, video monitoring and the automatic control system, and realized such functions of the mine as 3D visualization, comprehensive integration and alarm linkage.

The mining engineering plan in the AutoCAD software with dwg format, familiar to mine technicians(Li et.al, 2002; Guo, 2007), was directly used as virtual data resource of the 3D roadway of the mine in the system. In this way, the speed of systematic data update was improved, the workload in maintaining the system was extremely simplified, and the practicability of the system was guaranteed. The core value of the 3D comprehensive integrated mine management system lied in its realization of visualization integration. Specifically, it realized visualization of key positions of various integrated subsystems, including visualization

Please cite this article as: Wang P., 2016, Research and application of the 3d comprehensive integrated mine management system, Chemical Engineering Transactions, 51, 1021-1026 DOI:10.3303/CET1651171

of the position of monitoring points, simulation of escape route and personnel traffic, and display of mine video wall.

The core meaning of the 3D comprehensive integrated mine management system lied in its alarm linkage, which was realized by automatic tracking specific locations of alarm points. Through analysis of its influence surface, the system provided supplementary means for technical managers and corresponding emergence rescuers in decision making.

2.2 framework design and features of the system

Chapter 2 The system mainly constituted the apparatus level, the middle level and the demonstration level. What the apparatus level did was to monitor and record data such as personnel position, video monitoring, belt detector, gas extraction and roof pressure, its data being supported by mining engineering plan, layout of the monitoring facility and real space information. What the middle level did was to acquire and collect data from the apparatus level to establish database and undertake relative calculation. And the demonstration level outputted visualized information. Figure 1 showed the overall framework of the 3D comprehensive integrated mine management system.

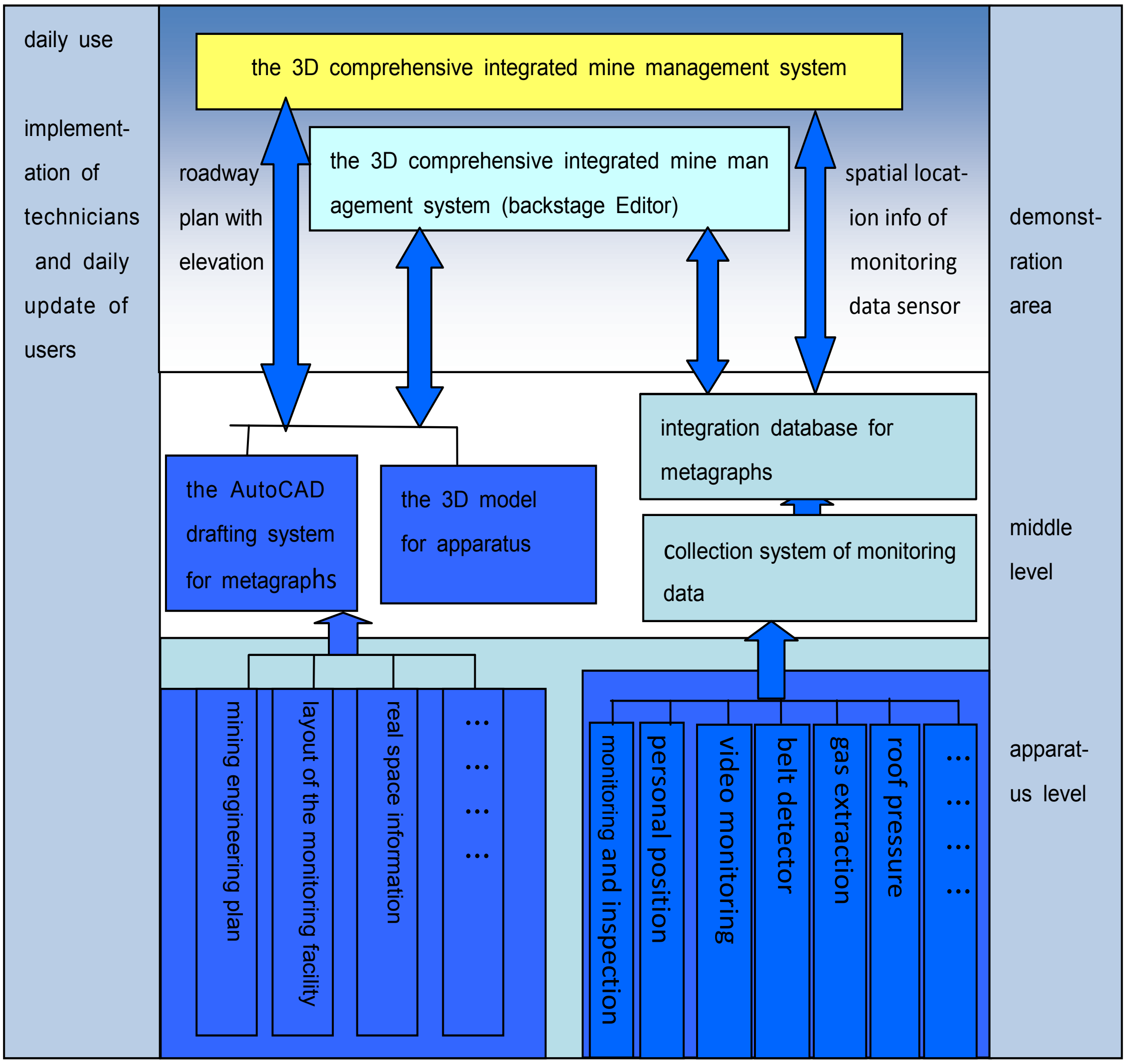

Figure 1: Framework design and features of the system

The greatest features of the 3D comprehensive integrated mine management system were: 1. As an existing seamless integrated system, it eliminated isolation of the information from the data level and realized alarm linkage; 2. The 3D base maps of the roadway in the system were directly originated from vector graphs in the AutoCAD software (with dwg format). It was extremely simple to update graphs as no transformation of formats was needed, and its demonstration effects were great; 3. The trace of personnel in the personnel position system followed the route of roadway completely, and could be automatically searched; 4. All of the scenes in the platform were free from manual modeling, instead, commonly-used interface protocols were realized by manual configuration. Therefore, the cost of the whole system decreased significantly. In addition, the system could operate as part of the supplementary monitoring and inspection program.

3. Functions and applications of the system

Taken Babao mine in Jilin province as an example, the paper undertook applied research on functions of the 3D comprehensive integrated mine management system, which had been put into practical use in Babao mine.

3.1 Outline

Babao mine affiliated to the Tonghua Mining Group of the Jilin Coal Industry Group (simplified as Tonghua Coal Co. Ltd). As zhazi mine, Babao mine used to belong to Tonghua Mining Bureau with an annual production of 3 million tons. There were totally six minable seams in Babao mine. Their grade classification of spontaneous combustion tendency was the level of II, which meant that they were spontaneous combusted seams. Babao mine belonged to high gassy mine, whose coal dust had the potential to explode. There were all together 5 shafts in Babao mine to be mined. The current deepest exploration elevation was 780m.

3.2 Case study of the system's application

(1) Establishment of 3D model of driven data

The process of 3D modelling included modelling and visualized expression of mine geology, automatic modelling of seam, fault modelling, roadway modelling, seep zones modelling, goaf modelling, collapse column modelling, sectioning of the 3D geology model, assistant design of the working face, and integration design of 2D and 3D.

The automatic modelling of seam took advantage of point data in Babao mine (namely drills, points to explore coal, traverse points, and modifying data of the practical coal) and boundary data (namely fault, collapse column and boundaries of the colliery) to generate 3D models of various seams and other strata rapidly. Through automatic modelling of drills, 3D models were generated automatically for data of drills for geology, hydrometry, gassy extraction, drainage, hydrogeology, and downhole drain. Through roadway modelling, 3D models for data from shafts, roadways, chambers, goaf, working face, bunker, sump and other downhole areas were established automatically, as well as realizing visualization of the cross section and interior of the roadway and other facilities. Data resources of the roadway were the mining engineering plan by AutoCAD (with the format of dwg). The sectioning system the the 3D geologic model could realize 3D sectioning of any geologic model, where geologic bodies could be sectioned on the computer screen directly with mouse by users for knowledge of interior characteristic of the geologic bodies.

With 2D&3D integration, dynamic data processing of the 3D platform was realized principally. With continuous deepened mining and constantly increasing downhole geologic data, control on working surface was more and more precise. The system could process dynamically updated data in real time and correct data error. GIS platform data was used to integrate mine, where effective control could be done on seam, fault, collapse column, old pits, ole workings, and even special location for gas and water. Data modification, data adding, data deletion and automatic update of data could be done in real time, including modification of the geological model and the goaf model and correction of errors in topological relations between roadways.

(2) Analysis and alarm linkage

Having fully considered that the main interface of the system was displayed on the scheduling screen, its simple design and straightforward display helped realize 2D & 3D integration as well as the function of linkage. Users could scan and walk in the interior roadway, which could be seen from outside when it was semi-open. Users could also gain quick access to the defined viewports, switch screens and watch automatic broadcast in turn that facilitated large screen display in the control center. The real-time data in the monitoring and inspection system was directly demonstrated, with double-click positioning of the monitoring points and graphical display. 2D & 3D integration could be displayed, or 3D interface could be displayed. Figure 2 showed the interface and switching figures of various viewports of the system for Babao mine.

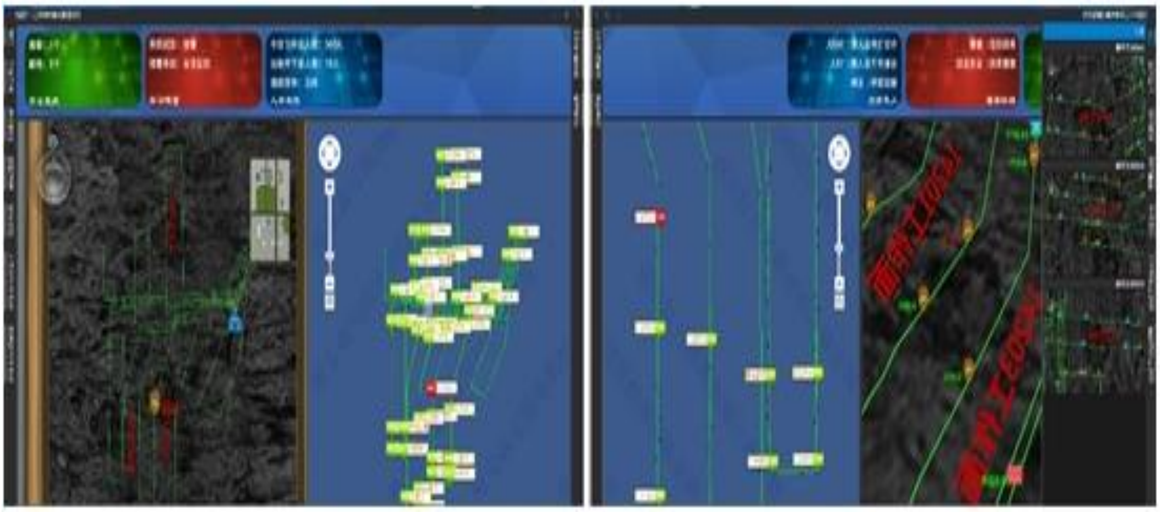

Figure 2: The interface and switching figures of various viewports of the system for Babao mine

Alarm linkage was the core of the system as well as a commonly-used function. After a certain alarm was launched, users could rapidly check new detection information in the alarm areas and call the police in an easier way. The system could also be used to simulate exercise. Figure 3 was the interface of retrieval of alarm linkage in the system for Babao mine.

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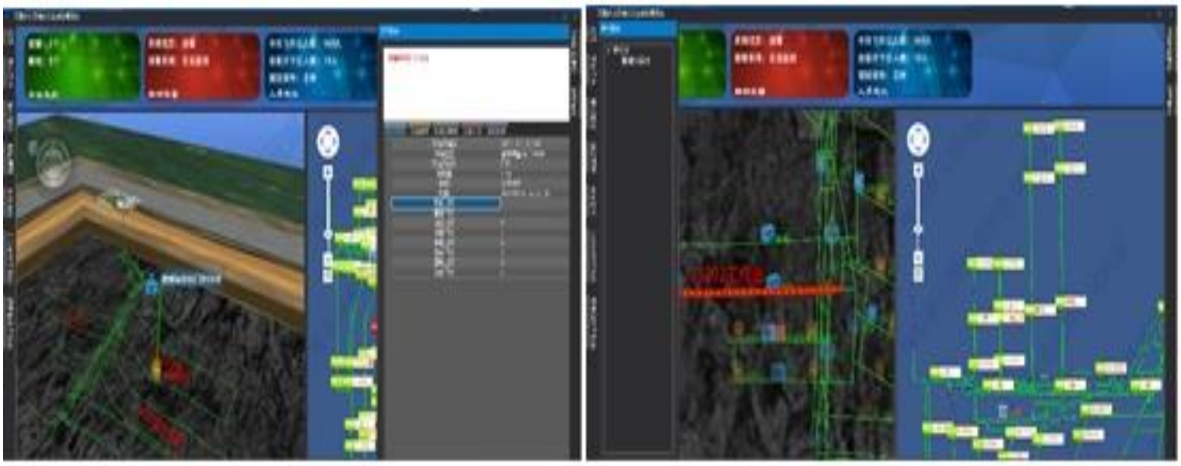

Figure 3: The interface of retrieval of alarm linkage in the system for Babao mine

(3) Integration demonstration of the production and operation system

The system gained access to production and operation data for security monitoring, personnel position, video monitoring and production automation with regards to mining, digging, transporting and dredging. 3D topological relation was used to generate the integrated interface of the production and operation system. In this way, 3D virtual scene and comprehensive automatic data were interconnected. The basic data for electromechanical devices would also be searched, inputted and modified, as well as monitoring the operation conditions of the apparatus in real time. Therefore, directors of Babao mine could gain quick access to the operating data of Tonghua Coal Co. Ltd.

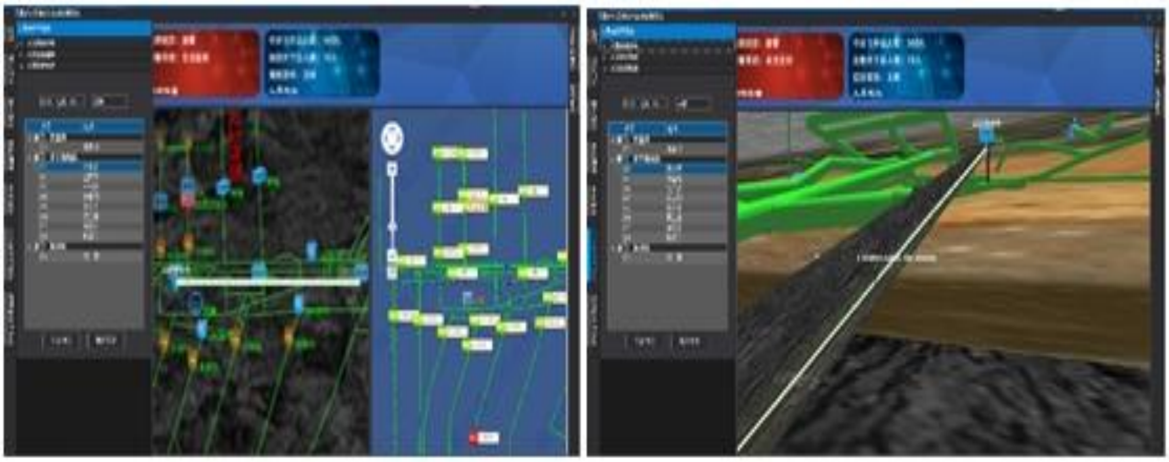

Figure 4: Personnel positioning and historical track playback of Baobao mine 3D Integrated Management System

With the system integration for production automation, such functions could be realized as UI-sources subsystem monitoring for production automation, interface development, roll titles development, subsystem switching, connection between the apparatus model and UI interface, and data access and data compilation. With system integration for security monitoring and inspection, the system could monitor UI sources, interface development, gas chromism, and abnormity warning and forewarning, and could transform data from industrial ring net and from informatization database into graphic data. The environmental parameters could also be visualized in a three-dimensional effect to display the distribution of objectives for test, such as gas, temperature and wind speed. Through the system integration for personnel position management, movement of one or more personnel of the downhole roadway could be followed and be recorded in the 3D scene in real time. Traces of the movement would be recorded for retrieval of targeted information. What's more, through personnel management panel, information of registered personnel under the mine could be scanned and searched. By visual display, one could identify every personnel. With integration application for the monitoring and management of the apparatus, the system could perform unified tracing and control on utility and maintenance of the apparatus in the 3D virtual environment. Based on 3D mining engineering plan, integration application for video monitoring realized position management of video sensors and video information display. Through retrieval for comprehensive information, basic information could be searched, such as colliery plan, reserves computation gragh, mining engineering plan, contrast plan between different seams, and information of drills.

4. Conclusion

Practices showed that this system achieved positive effects in its application to Babao mine. The system solved such problems as isolated information for the previous monitoring, achieved 3D visualization and 2D & 3D integration with straightforward display and timely data update. The alarm linkage in the system greatly facilitated production monitoring and emergence rescue of Babao mine. In addition, maintenance of base map in the system was so easy that the mining engineering plan in AutoCAD with dwg format could be directly used as data resources of virtual 3D roadway of the shaft. The advantage of it lied in that system data could be updated more rapidly, that the maintenance workload for the system was greatly simplified, and that the practicability and lifetime of the system were increased significantly. Research on the system and its successful application to Babao mine were of great significance to further development of high-end informatization and intelligentization.

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