Digital Mining Technology-Based Teaching Mode for Mining Engineering

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***Abstract*—In this paper, the main problem in present mining engineering teaching was analyzed. Based on the analysis, the study of bringing digital mining technology into mining engineering teaching was presented. Furthermore, a new mining engineering teaching mode that includes mining knowledge demonstration, mining expertise building, mining environment modeling, and creative mining thought was also presented. In the teaching mode, 3D digital mining technology was used to model the mining environment. The modeled environment facilitated a systematic mining teaching system that helped students understand both mining concepts and mining operations. Thus, the instructor, student, and mining workers were essential to the teaching mode. The use of digital mining technology and relevant multimedia made mining teaching vivid and easy to be understood. Digitized primary data in mining engineering were readily and visually understood by students. Simulated 3D mining scenario generated with the data helped students understand theory and practice. Meanwhile, application of distant information technology helped mining workers in the abovementioned mining engineering teaching mode to be involved, thereby providing first-hand experience for classroom mining teaching. Hence, the digital mining based mining engineering teaching mode shows considerable promise in raising teaching effectiveness and efficiency.**

***Index Terms*—digital mine, mining teaching, environmental reconstructing, virtual reality**

I. INTRODUCTION

Driven by scientific and technological development, computer science, information technology, and 3D simulation are used in mining engineering [1–2]. However, mining engineering teaching in the classroom continues to be conducted via concept explanation with 2D drawings that are difficult to comprehend. The teaching mode normally ends up with students becoming bored, having limited understanding of the mining industry, and lacking of mining technical depth. Considering this situation, the application of digital mining that is capable of vivid 3D mining demonstration could be an effective way of teaching mining engineering. With this type of teaching mode, students will then have deep understanding of the industry and will enhance their technical knowledge in mining engineering.

In this paper, study on the application of digital mining technology in mining knowledge demonstration, classroom teaching, and mining practice conveying is presented. The specification of mining concepts, engineering process, daily operation, and conventional mining teaching method are also discussed. A teaching mode that follows the instructor, student, and mining worker based on multimedia and digital mining tool is proposed.

II. STATE OF THE ART

Implementation of resource saving and environment-friendly mining strategy is the key to consistently develop mining talents with innovative thought [3–4]. Improvement has been witnessed among students in terms of mining technical depth and industry understanding. However, some provocative problems remain unsolved.

A. Boredom

The systematic mining teaching mode that is discussed in the introduction of frontier study into classroom teaching is restudied to improve students' understanding of what was previously taught [5]. The seminar-based teaching mode was also proposed to further help students understand mining theory and practice [6].

At present, mining technical knowledge is conveyed to students mainly via books. Abstract mining concepts in rock mechanism, machine construction, and mining process are normally difficult to understand, especially when several concepts are imposed for students who are beginners. As a result, students show boredom in their study of mining technical knowledge.

B. Comprehending difficulty

Research on mining practice that instructs mode research and emphasizes mining practice training is examined [7]. The virtual reality mining engineering teaching mode that features diversity and hierarchy is also proposed to help bridge the gap between the classroom mining teaching and everyday mining operation [8].

Internship is believed to be an effective way to help deepen students' understanding about mining engineering. However, its effectiveness in mining enterprises turns out to be unsatisfactory for safety concerns and the limitation of difficult production schedules. Students see only scattered pieces without first-hand experience. Thus, they cannot understand the meaning of these pieces mean. . This situation is further worsened by limited internship budgets.

C. Gap between theory and practice

The gap between classroom mining teaching and mining operation was studied. On this basis, a mining engineering teaching mode that features extensive lab teaching and enterprise practice learning is presented [9]. The introduction of a mining company into mining engineering teaching to bridge the gap between theory and practice is also proposed [10].

Real mining operation features the disconformity and complexity of mining expertise and management practice in different mines. Therefore, most students have difficulty understanding the commonalities and differences using the abstract concepts memorized from the textbooks.

III. DIGITAL MINING TECHNOLOGY

Digital mining technology refers to the framing of networking, digitization, modeling, visualization, integration, and management of production, operation, and management of mining engineering using technology in information, database, sensor networking, and intelligent process management [11–12].

Digital mining technology is typically cross-discipline. Based on computer simulation, virtual reality, and communication techniques, digital mining is the systematic combination of basic science theory and the technology of space information, digital geology, modern mining theory, communication, automatic control, supervision and inspection, and operational research [13–14].

The definition of digital mining itself shows the feasibility in applying theory and techniques of digital mining in mining engineering teaching. Big data-based digital mining technology is capable of vivid 3D demonstration of the actual everyday occurrences in a running mine. The students can use this technology to build mining models and plan mining operations. Digital mining technology can be applied to mining engineering teaching.

IV. A NEW TEACHING MODE

Adjusting the existing teaching support environment in the digital mining technology based teaching mode focuses on the instructor, the students, and the mining workers. Multimedia and digital mining tools are used to facilitate the dynamic interaction among classroom teaching, actual mining operation, and virtual reality of mining engineering. Figure 2 shows the theory, practice, and virtual reality teaching mode for mining engineering using digital mining technology. In this mode, mining theory and practice are combined. With the help of mining workers, comprehensive understanding of theory and practice is readily available for students.

A. Visualization of mining engineering

Mining engineering involves geology, survey, mining, and safety. Rock mechanism, mining design, mining ventilation, openings, and development engineering lay the foundation for mining engineering. Thus, these subjects are related to geology, survey, and safety. When building mining engineering teaching framework, big data that concerns geology, survey, mining, and safety should be properly used.

Digital mining technology enables the development of databases that incorporate data from mining geology, survey, mining, and safety. The relevance of the data can be vividly demonstrated in the digital mining platform. The teaching context can also be allocated to meet the needs of the instructor, the students, and the mining workers. Figure 3 shows the 3D demonstration of geology data and the corresponding mining body model.

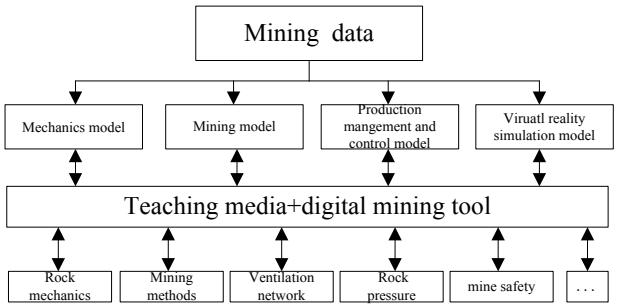


Figure 1. Feasibility model

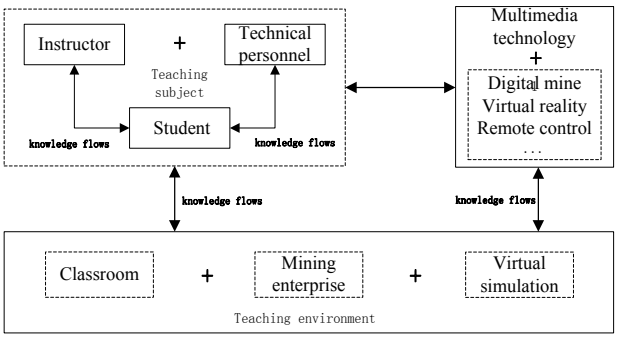
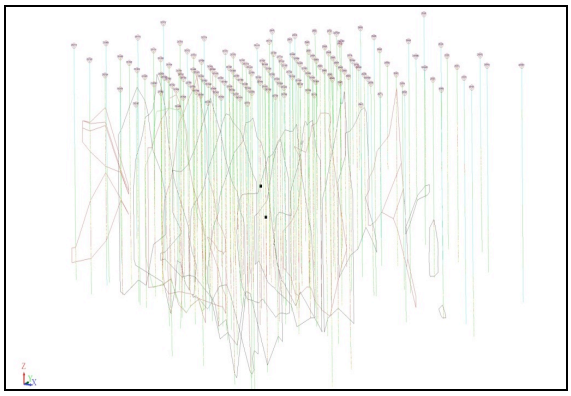
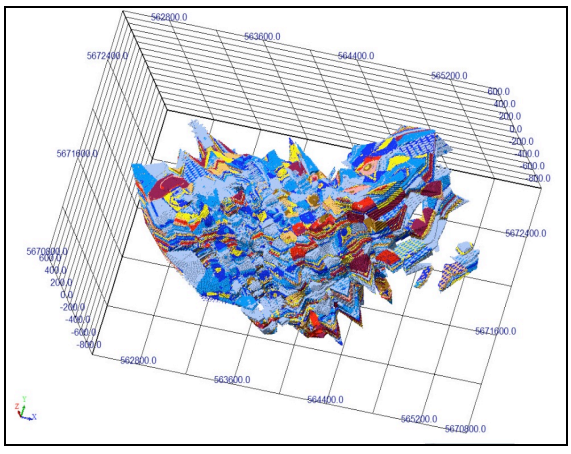


Figure 2. Digital mining technology based teaching mode

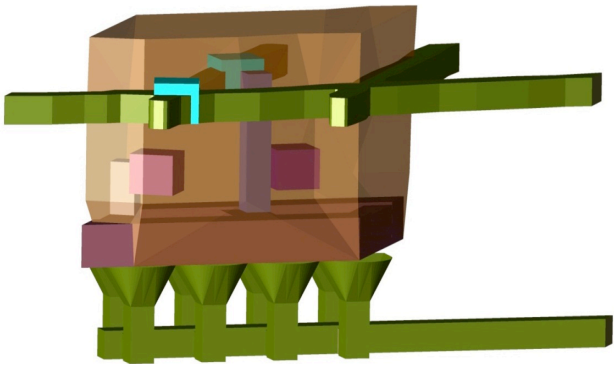


(a) Geology data

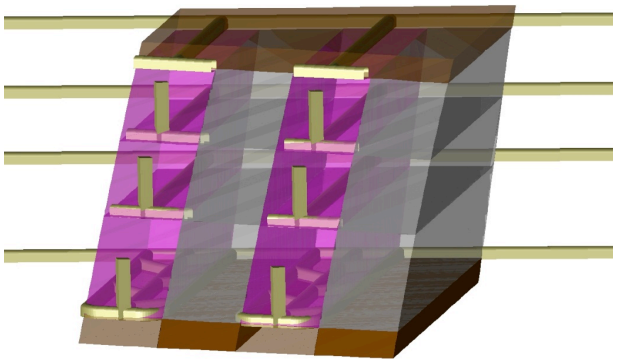


(b) Mining body

Figure 3. 3D demonstration of geology data and corresponding mining body

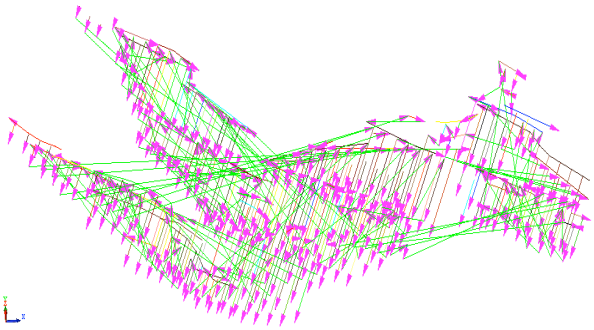


(a) Caving mining

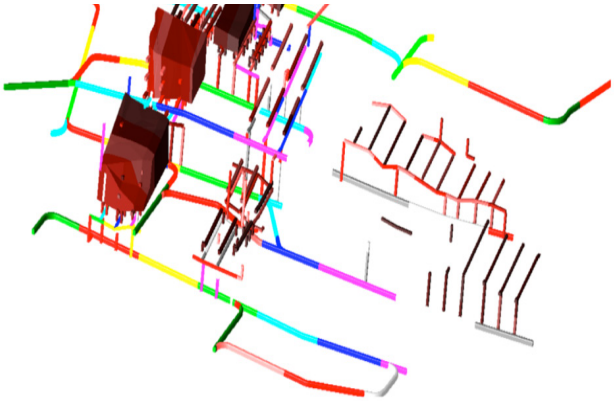


(b) Open stope mining

Figure 4. 3D demonstration of geology data and corresponding mining body



(a) Underground mining production planning



(b) Production planning demonstration

Figure 5. Underground production planning

B. Teaching with 3D simulation

Digital mining tools make mining data analysis possible, be it 2D or 3D. Thus, such data could be visually demonstrated. Given digital mining tools, the mining process can be shown in 3D model, thereby reflecting its flow, property, and dynamics.

In mining engineering teaching, 3D simulation can greatly facilitate the understanding of abstract concepts and everyday mining operations. Students can then build mining models using digital mining tools. Figure 4 shows the simulated 3D mining process.

C. Teaching specification

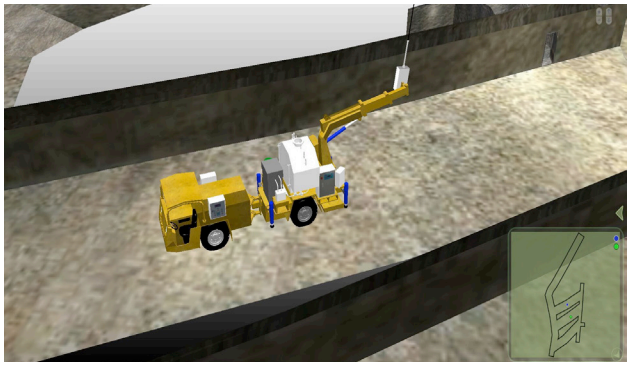
The purpose of learning is to apply lessons that have been acquired to everyday work. This principle is also applicable to mining teaching. Development of students' ability in transferring what is learned into mining production is essential. Therefore, students should command a solid understanding of mining engineering and receive proper training in mining practice.

Mining operation involves mining production and mining management. In essence, these factors concern the proper allocation of workforce, resources, and property. Digital mining technology lays the foundation of mechanical analysis, mathematical calculation, and status assessment that are vital for mining production and management. Using digital mining technology, students could receive practice training in rock stability, ventilation optimization, and production planning as well as training in innovative mining thinking. Figure 5 shows the 3D demonstration of an actual underground mining production plan.

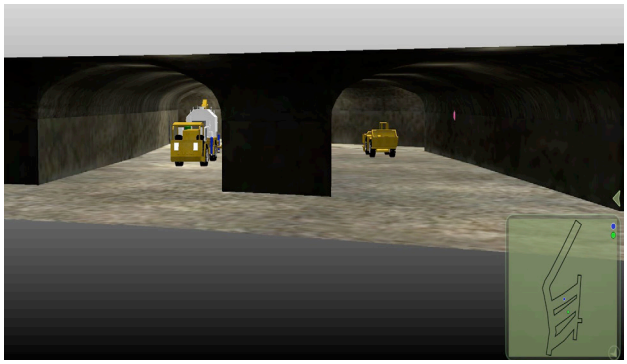
D. Mining prospective mapping

Bringing promising cutting–edge study into classroom mining teaching can help instill knowledge on mining among students. By contrast, the development of automation and intelligence science in mining can be studied using classroom mining teaching textbooks.

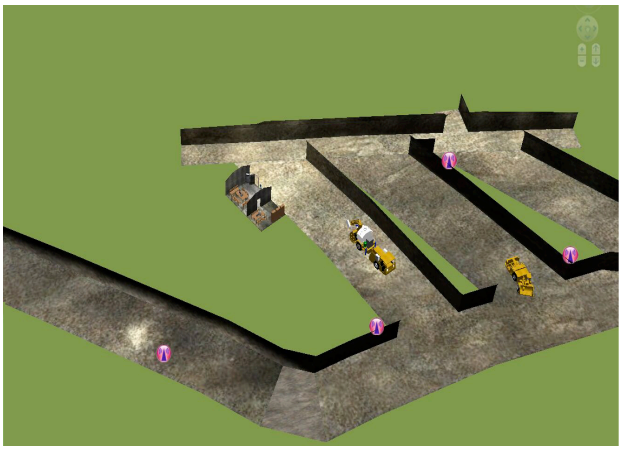
Frontier study in mining is common. Interesting topics include automatic scraper, rock driller, pit cars, and intelligent dispatch and control. Demonstration of mining equipment to execute movement control, walking path planning, workflow design, and intelligent dispatch using remote control and virtual reality can help deepen students' understanding about mining engineering. Demonstration of these frontier studies can also help increase students' interest in mining engineering learning. Figure 6 demonstrates certain intelligent mining techniques.



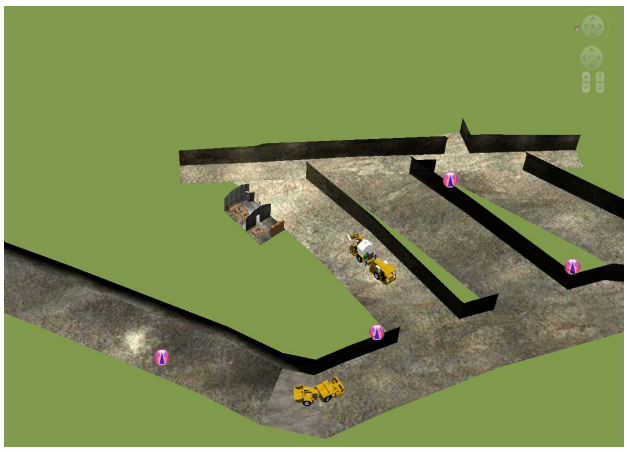
(a) Loading truck



(b) Driller and scraper



(c) Dispatch



(d) Dispatch

Figure 6. Intelligent mining techniques demonstration

V. INNOVATIVE PRACTICE OF TEACHING

Tests were conducted to test the effectiveness of digital mining technology in mining engineering teaching. Virtual reality practice teaching through the preceding trials mainly involves mining modeling, mining production simulation, and optimization.

A. Mining modeling

Digital mining software is used by students to model mining and its relevant equipment. Figure 7 shows the 3D simulation work by the students.

B. Virtual reality based mining

The simulated 3D models are projected into a virtual reality platform. By manipulating these models in the platform, students can gain a first-hand mining experience. Further, remote control could be engaged to map virtual models with actual mining layout. Figure 8 shows the simulated virtual reality of mining engineering.

C. Mining operation optimization

Mining operation optimization targets the flow of mining engineering using the optimization of production parameters. Parameter optimization requires solid understanding of mining production and helps foster creative mining thinking and establish better technical mining solutions. Figure 9 shows the 3D demonstration of open-pit mining planning with digital mining technology.

VI. CONCLUSION

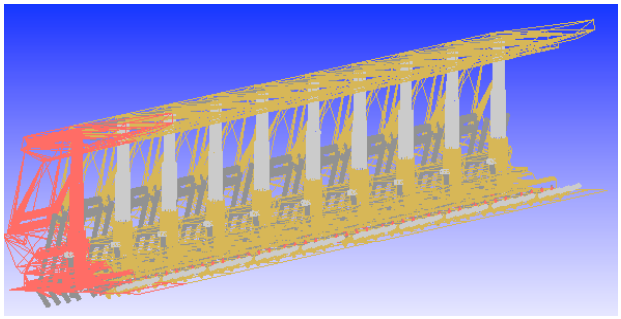
In this paper, a mining technology-based teaching mode that features the interaction among instructor, student, and mining workers is presented. Based on the teaching mode, classroom teaching, mining production, and virtual reality of mining engineering are also discussed. The conclusion is summarized as follows:

(1) Application of digital mining technology in knowledge transmission, mining scenario building, mining production, and management teaching help improve students' interest in mining study and narrow the gap between theory and practice.

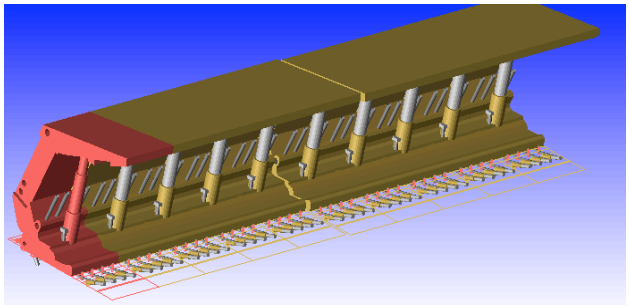
(2) The concept of instructor, student, and mining worker collaboration is presented. A mining teaching mode based on classroom teaching, mining operation, and virtual reality is then discussed. Thus, the teaching mode is of considerable help in classroom teaching, practice for instructing, and case study.

(3) 3D visualization and virtual reality are introduced into mining teaching to help students better understand the fundamentals of mining. Mining data-based practice helps students with theory application and innovation.

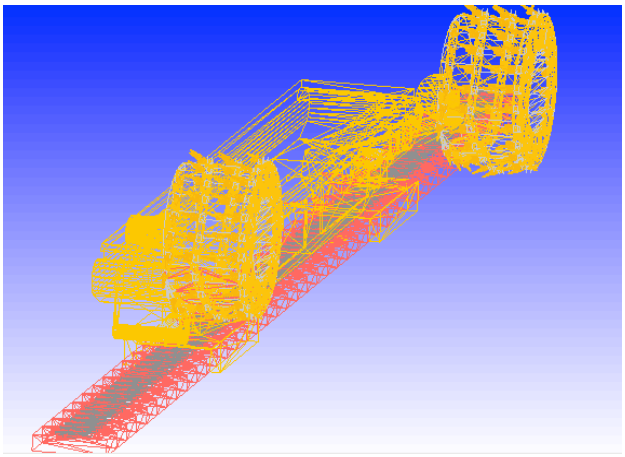
A digital mining-based teaching mode is introduced in this paper. The application of digital mining technology in mining teaching was considerably helpful. However, the proper combination of software and hardware should be established if expected teaching results of digital mining technology are to be realized. Therefore, studying the introduction of different digital mining techniques into mining teaching is necessary to help standardize and systematize the digital teaching mode.



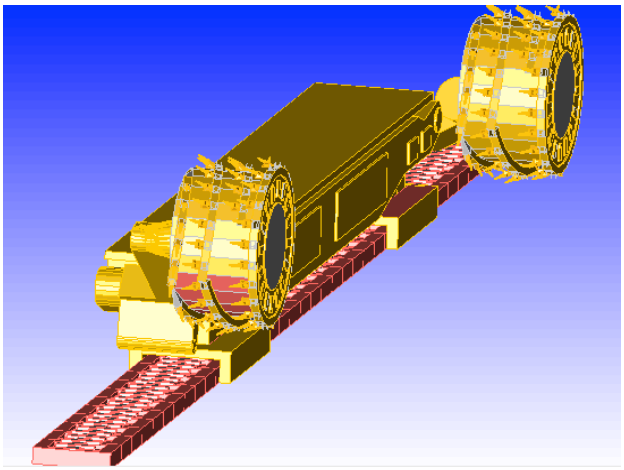
(a) Trestle model



(b) Trestle body

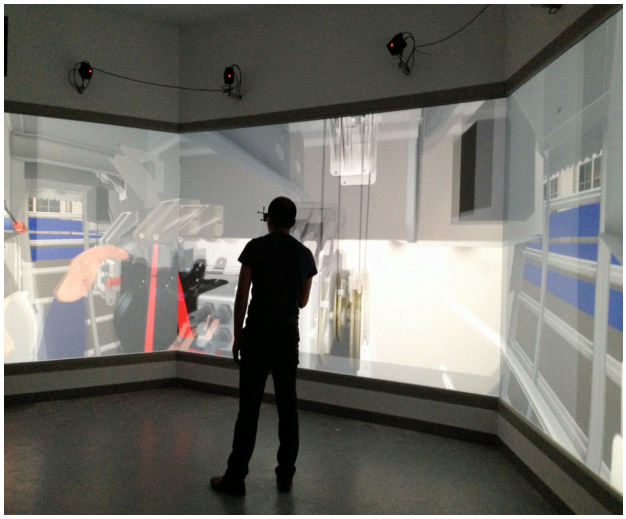


(c) Coal cutter



(d) 3D Coal cutter

Figure 7. Simulated mining engineering work

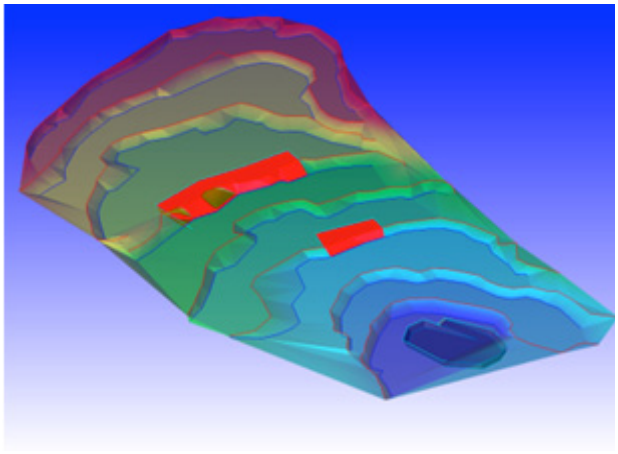


(a) Virtual reality platform

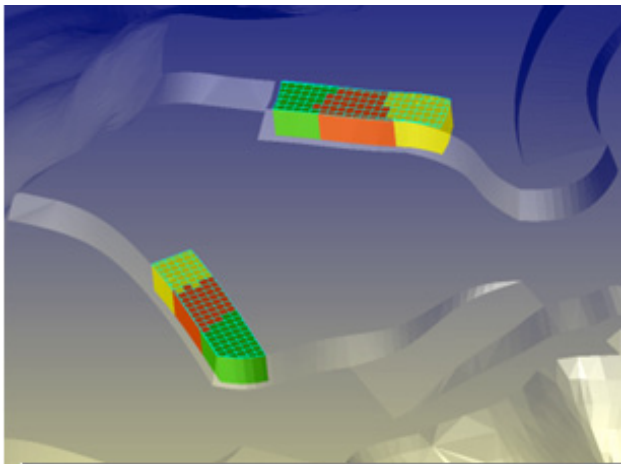
(b) Opening and development

(c) Refuge chamber

Figure 8. Virtual reality based mining simulation



(a) Open-pit mining planning



(b) Ore block mining optimization

Figure 9. Open-pit mining optimization

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