A Role of Information Technology in Geotechnical and Mining Engineering for the Past, Present, and Future

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Abstract

In this paper, the development of information technology is divided into three parts: 1975-2000 (past), 2000-2025 (present), and beyond 2025 (future). During the last century, mainframes were considered topmost in terms of processing power. However, with the evolution of personal computers and laptops, computational power has increased in an exponential manner, and at the same time cost of hardware has dropped substantially. Various tech giants are famous for their specific products, such as Microsoft for their MS Office, Oracle for databases, routers from CISCO, and SAP for ERP. In the mining industry, information technology has always been used as a supportive role in various functions such as exploration, drilling and blasting, production and quality monitoring, financial accounting, inventory management, and dispatch of the minerals. The computer science department or information technology department has become crucial to support all functions in geotechnical and mining engineering. Various exploratory and mine planning software such as Surpac and Data Mine are commonly used for exploration and short to long-term mine planning. With the increase in processing power, even the mobile phone has become a powerful and essential device for communication. With enhanced power of the camera and increased data storage, internet connectivity, several useful applications are developed on mobile phones. Various OEMs have their own software for monitoring mining equipment which has benefited mining companies. In the future, artificial intelligence and machine learning models shall be applied in a geotechnical mining operation to improve productivity, safety, and sustained mining operation.

Keywords: Artificial intelligence, Drilling and blasting, Information technology, Machine learning, Mine planning software

1. Introduction

Information technology is well known since the last century for the creation, processing, storing, retrieving and exchanging of every type of electronic data. Mainframe computers slowly decreased from the 1950s to the 21st century with the introduction of

intel chips and personal computers [1]. In 1965, Golden E Moore made an observation that the number of transistors on a microchip would double about every two years, though the cost of computers would be halved [2]. His prediction, even after 50 years, appears to be correct. In the mining industry, personal computers were introduced in 1990 [3]. Mining, whether opencast or underground, is a complicated process having many dimensions. Initially, linear computerised models were developed to solve operation research-related problems. Long-term scheduling was always challenging in order to solve how any deposit could be economically mined with a long time span. Computers and quantitative techniques played an important role in solving scheduling problems in mine planning and comparing the progress of mine faces in operation by taking into consideration geology of the deposit, overburden or inter burden [4]. Transport cost optimization of dump trucks and loading was the priority. Handling of overburden and storage of the same with minimum cost was challenging. Lack of computer models at mine site was the main big disadvantage during early computerisation. Experts were available at the central corporate office. Much of the time was spent on understanding the problem at the mine site and discussing with the computer experts and specialists at the mining organization's computer centre, grasping the problem by them and making them interested with mine experts or mining operation personnel. Several times the process was repeated to understand the solution, developing belief by mines management and permitting to test solution to achieve the results. This created frustration and misunderstandings among team members leading to futile efforts. Further experiments were blocked without knowing real or anticipated difficulties. Also, there was a difficulty in training mining and geotechnical engineers who could act as computer experts. As a general rule, all models for the mining industry were expected to be menu-driven with self-explanatory and with help support. However, there was a change in the scenario as cost economical Personal Computers (PC), and later laptops were evolved. Microsoft came up with its operating system, which became most popular among all users. Thus computing capacity was locally available for geotechnical and mining engineers at the site or the office and making efficient operation. There was also improvement in the internet networks-Wide Area Network (WAN) and Local Area Network (LAN). Various mine planning software was evolved, such as Surpac, Data Mine. Explosive companies developed various software for the prediction of fragmentation, ground vibration etc. Many software programmes were developed for the maintenance of mining equipment. During the 1990s, large mining organizations started implementation SAP ERP software. Oracle is one of the large database software companies having an 80% market share. CISCO company has a majority of routers that are used in mining and other industries.

Figure 1 shows how the demand for various electronic items and gadgets have been increased. The first million radio sets were sold in 65 years. It took eight years to sell the first million TV sets. The first million PC's were sold in 3 years. On the other hand, the first million laptops were sold in 1 year. The first million mobile were sold in less than one year. Presently, the new models (1 million sets) of any mobile premium company are sold in a couple of minutes.

This paper further discusses the present (2000-2025) era of information technology and the future (2025-2050) expected

development in Information Technology which will benefit Mining and Geotechnical Engineers.

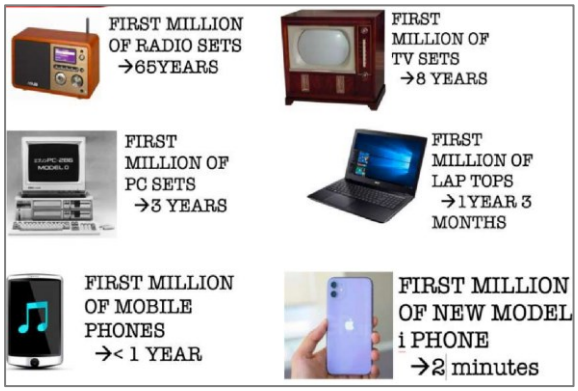

Figure 1: Technological revolution where the demand for various electronic gadgets has increased exponentially.

2. Present Era of Information Technology

Various artificial intelligence/machine learning techniques are applied in the present era for the prediction of performance, optimization or minimization of any mining operation or maintenance issues of mining equipment. Following are some of the algorithms discussed.

2.1 Artificial Neural Network

ANN is a part of Artificial Intelligence, along with Case-Based Reasoning, Expert Systems and Genetic Algorithms. An information processing system is similar to the human brain in structure and functions. ANN is capable of 'learning' to 'recognise' a complex input pattern and predict the output pattern thereof. The network is then able to recognise similarities in new input patterns and can predict the output. This property of a neural network makes it very useful for noisy (inexact) data to be interpolated and outputs predicted in terms of patterns that are already 'known' to it. ANN has three fundamental components [19] Transfer Function, Network Architecture and Learning Law.

2.2 Network Training

The BPNN consists of three layers: Input Layer, Hidden Layer and Output Layer. Daisy Chain – layer using neurons. Neurons under changes in Hidden Layer and Changes to Neurons are determined via transfer function. The transfer function acts as a filter. The transfer function is designed to map the output received from a set of neurons or layer of neurons to the pre-recorded actual output and establish a pattern.

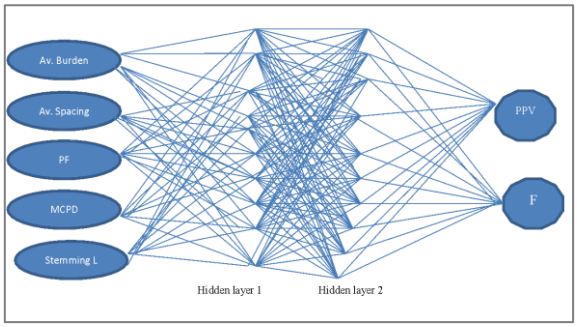

Figure 2: Example of prediction of ground vibration due to blasting using artificial neural network [5].

Three waves of machine learning are shown in Figure 3. During the 1950-1980s, Chinese people had a vision of computers as "Electronic Brains". During 1980-2010, powerful and efficient algorithms were developed for research purposes instead of industry. The present trend is data-driven machine learning with powerful and efficient algorithms.

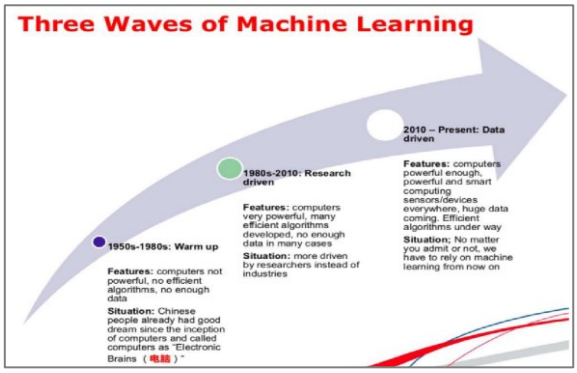

Figure 3: Three waves of machine learning [6,7].

4. Future of Information Technology

Information Technology will be driven by the data of customers. The data from mining operations shall be captured at every stage and stored in cloud storage. For obtaining data, knowledge of digital engineering will be necessary. Resilient decisions can be

taken with ample data/ Information technology will be playing a crucial role.

Figure 4: Competency of the future

5. Conclusions

During the last 50 years, information technology is evolving as computer processing power has increased exponentially. On the other hand, the cost of hardware has dropped tremendously. With the application of the Internet of things, improvement in computer proficiency among professionals and ease in availability of hardware, the mining industry is benefited.

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