

A Conceptual Metrics Model for Tracking the Usage of AI/ML-Based Application for Health Monitoring of Mines Workers in Mining Organizations

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ABSTRACT:

The objective of this work is to present miner's health monitoring metrics framework/system which provides KPIs of the current state of the occupational health for mine workers and provides insight about the usage of AI/ML applications for health safety & environment. We are proposing a model which can be used by mining companies for better management of mines environment and worker's safety & wellbeing.

In mining, even modest increases in productivity, safety and efficiency can have a significant influence on a company's profitability in the highly competitive business world of today. Health & Safety managers strive for any advantage at every level of the mining process using technology, whether it is through better safety, shorter lead times, less waste, less downtime, or higher quality. The idea is being applied in a variety of industries, and it is being aided by increased production, safety, and operations. In current era of AI/ML & IoT there are many companies, which are using AI/ML-based applications to control & monitor worker's health and safety (Vinuesa et al., 2020).

It is a significant piece of technology that many organizations utilize. It has also been utilized by numerous international mining corporations to improve health, operational effectiveness, productivity, and safety (Bigolin et al., 2021). Indian companies have also started using it in small way which is helping management in better health & safety management at the plant/mines.

One of the key challenges in AI/ML application implementation is measuring the success rate and effectiveness & efficiency of the AI/ML models used. To ensure best results there is a need for a metrics model/framework which will support in better tracking & usage of AI/ML system specifically for mine environment and miner's health monitoring.

This paper explores the possibility of usage of a conceptual metric framework for AI/ML-based health and environment monitoring applications. The proposed framework will help in tracking the usage of AI/ML-applications in Mining through a pre-defined set of metrics.

Keywords: Mining, Model Effectives, Usage of AI/ML, Metrics, Health, Safety.

INTRODUCTION:

Mining is a very old occupation, being recognized as a job which has high risk of injury and disease. Mining is a multi-disciplinary industry, drawing on several professions and trades. To ensure precision in clinical and epidemiological work, it is important to enquire about the details of tasks, as the term miner is relatively nonspecific. Miners are exposed to various potentially toxic or harmful materials or agents like fuels, reagents, solvents, detergents, chemicals, coal dust, silica dust, asbestos, noise, welding fumes, metal dust etc. As a result, a number of disorders develop through the passage of time.

Indian mining sector has a major role in nation's development and economy (Hazra K Arnab, 2013). It is distinguished by a significantly lower level of maturity in terms of technology, methodical planning, sustainability, and business processes, as well as a limited adoption of common quality, AI/ML and other frameworks. The mining industry, being one of the most hazardous industries, places considerable responsibility on the miners and other stakeholders. Operating an effective and efficient business in a healthy environment is very important for the future sustainability of the business in the industry that is experiencing issues including worker's safety, shifting demand, cyclical pricing, and decline in profitability (Hilson & Nayee, 2002).

The industry should investigate development potential through innovation, cutting-edge technology, and process improvement & quality frameworks for good health, higher productivity, safety, and sustainability in the current competitive and volatile environment. The mining sector in India uses a lot of machines, deploy workers, and needs to pay attention to reducing the loss of important life & assets, which may be better managed with the use of AI/ML and other technologies. Many organizations from other industries have benefited greatly from AI/ML in terms of increasing safety, the utilisation of equipment, labour, and other resources (Vinuesa et al., 2020).

The mining sector may establish a safer work environment and reduce the hazards involved in mining operations by implementing safe mining practices & technologies and placing a priority on the well-being of miners. The mining sector should work towards a future where mining is not only productive but also safe and sustainable through ongoing improvement, training, and technological advancements (Choi, 2023).

Research reveals that effective use of AI/ML system has been a big challenge and that there is a lack of coherent & conceptual models to ensure better applications & usage in the industry. It demands innovative systems and frameworks. So, there is a need to suggest a metrics framework which would help to achieve better results in miner's health monitoring & sustainable mining operations. The paper suggests the usage of metrics model in mining for monitoring & tracking of AI/ML applications & related metrics across the organization with a special focus on miner's health and safety.

LITERATURE REVIEW:

CHALLENGES OF MINING INDUSTRY:

In 2023, growing expectations around sustainability, climate change and license to operate, as well as a more uncertain geopolitical environment, will top the agenda for mining and metals leaders. Global disruption will also put new pressure on costs, productivity and workforce, prompting companies to explore opportunities to reimagine business models and accelerate innovation. The question is, how can mining and metals companies navigate immediate challenges, such as rising costs and supply chain disruption, while progressing their transformation into purpose-led, low-carbon, digitally enabled organizations? As we head toward 2024, the mining and metals sector is responding with more fundamental shifts to business and operating models. New business models offer opportunities for miners to reposition for a changing future, with many companies considering the benefits of strategies to rationalize, grow and transform (Deloitte Research, 2020).

The time when miners could merely search for minerals has long since passed. Future miners who also mine for innovation will be successful. In order to maximize their use of talent and financial resources, businesses must internally develop new systems and processes. They must also take into account obtaining new tools & systems from outside their organization if doing so offers them a more durable course of action. In the upcoming years, managing the firm will necessitate new procedures and norms for both sorts of "innovation mining" (ABB Research, 2020; Deloitte Research, 2020).

MINE WORKER'S HEALTH RELATED ISSUES & CHALLENGES:

Mining is a unique profession that necessitates special training, monitoring and culture because it involves navigating below surfaces and across wide chasms. Workers encounter novel issues and an unfamiliar environment both underground and even in open channels (Morteza & Mahdi, 2014).

Mine workers often need healthcare services in order to continue working without discomfort, making accessible and affordable healthcare a necessity. As the duration of working in mines is prolonged, there is a high chance of having an adverse effect on health (Ahmad, 2019).

Safety is a key factor for mining activities because the regions have severe temperatures, air quality, and effects. It impacts workers health and affect their productivity & safety. Due to their lack of knowledge, sporadic employment agreements, poor application of mining law, lack of government oversight of mining activities, and the profit-maximizing practices of the mines, the workers hardly ever receive compensation as required by the Mining Act and Mines Safety guidelines. As a best practices, authorities have recommended a set of principles, including the employment of an adequate number of qualified health social workers/human right professionals both at micro and macro levels, and developed an appropriate plan to ensure the health and wellbeing of mining workers. Additionally, it's crucial to follow mining regulations strictly, conduct regular social and environmental impact assessments, offer permanent employment contracts to workers, ensure their social protection and security, and

build out a sufficient health infrastructure in the mining community. All these initiatives should be supported by a healthy culture and latest technologies along with a structured monitoring systems (Ng Corrales et al., 2022).

The well-being of miners and the maintenance of a safe workplace depend on the creation of a safety culture in the dynamic and frequently dangerous world of mining. The idea of safety culture refers to a grouping of attitudes, values, beliefs, and perceptions that exist inside an organization and foster a common commitment to safety and a desire to reduce harm. The culture can be developed and built through collective engagement, effective communication and technology (Ahmad, 2019).

High standards for safety processes and procedures should be established by strong (mining) safety systems and cultures, which lay the groundwork for a secure workplace. It will instill a proactive mindset to recognize and reduce potential risks, going beyond merely adhering to rules and procedures. Mining firms should emphasize the significance of each employee's well-being and make it a shared responsibility across all levels by making safety an inherent part of the organizational DNA (Nemati et al., 2019).

Building a great safety culture also requires encouraging open dialogue and employee input. A better working environment is produced when employees are given the freedom to express their concerns, report risks, and recommend improvements. Their own knowledge and perceptions may reveal potential dangers or weaknesses in current procedures. Mining businesses can benefit from workers' knowledge, strengthen safety protocols, and promote a continuous improvement culture by actively incorporating them in the safety decision-making process. Additionally, a strong safety culture not only lowers the risk of mishaps and injuries but also improves overall operational effectiveness. Deeply entrenched safety precautions are easily incorporated into regular work routines and form an essential component of standard operating procedures. As a result of enhanced worker compliance with safety regulations, productivity increases and unplanned downtime from accidents or incidents is reduced. A safety-conscious and healthy staff also promotes confidence among stakeholders, demonstrates a commitment to ethical mining practices, and enhances the reputation of the sector (Nemati et al., 2019).

A multidimensional strategy that includes leadership commitment, thorough training programs, continual communication, and constant reinforcement along with technology is needed to develop a strong safety culture. Mining businesses must spend money on thorough safety training to provide workers the know-how and abilities to spot and handle any threats. By setting an example and making a public commitment to safety procedures, leadership is essential in creating a culture of safety. Along with all above mentioned initiatives, organizations should put a safety & health improvement and monitoring program in place.

We have observed that, many organizations have put a monitoring system/program in place. Despite the legal need, issues could develop if such crucial programs are not routinely monitored by people in positions of responsibility, causing health surveillance programs to lapse and leading to unintended health repercussions on mine workers.

Along with safety culture, organization should try to implement a health monitoring and transformation tool/system using latest technology. One very important and suitable tool for transformation of health management system in mining companies can be AI/ML-based systems. Many organizations have implemented AI/ML applications in different areas & function of mining and getting business benefits. However, there is lack of a structured metric model/framework, which can help in better usage of AI/ML models in mining. The new proposed model can be attempted for mining industries for better results.

TECHNOLOGY USAGE IN MINING INDUSTRY:

One of the most dangerous jobs is mining. The lives of miners are impacted both directly and indirectly when fundamental rights are not upheld. Engineering and managerial risks frequently result in issues with stability and the well-being of miners in complicated mining operations. To improve mine safety and to ensure a safe and effective mining operation, advanced technology research, application, and promotion are crucial.

The modern world's escalating industrial and technological demands heavily rely on minerals. To meet the need for minerals worldwide, the mining industry is pushing the boundaries of technology, which will eventually lead to specialised safety-related issues. The issues of mining safety are being addressed with increased rigor as a result of the development of modern technologies and the advancement of science and technology. These cutting-edge methods have the potential to revolutionize mining and increase the safety, health, and productivity of resources.

Nearly all of the actions that are done in the mines endanger human life. For instance, rock falls could happen in deep mines, and if they were to strike a person, the result could be catastrophic injuries or even death. While coal is stable underground, exposure to air during and after mining can cause low-temperature oxidation, which can lead to self-heating and, in severe situations, spontaneous combustion. Numerous technological advancements have been made to reduce the likelihood of such mishaps. Different antioxidants have been added to reduce the likelihood of coal spontaneous combustion, while rock bolting technology has been developed to address the issue of rock falls.

Rapid advancements in technology, such as automation, digitization, and electrification, have a big impact on the mining sector. Drones, automated drilling and tunnel boring equipment, smart sensors, autonomous vehicles, and other advancements are changing the mining business. The advancement of technology has led to the adoption of safer mining practices. Safer mining operations include smart alarms, smart analytics, safe underground movement, and safe evacuations. The changing technological landscape requires a continuous monitoring system for workers, mines and organization.

AI/ML AND ITS USAGE IN MINING INDUSTRY:

In the current competitive global economic environment in which business is operating in, key resources and the way they are managed are becoming increasingly important. Usage and implementation of AI/ML in the mining industry started few years ago. Over the years, it has

provided some benefits to the mining industry through cost reduction, productivity & quality improvement, and better safety. Mining and metal industries have been using AI/ML based on business context, needs, internal and external environment. It's helping companies in achieving some benefits, but more can be done by working towards further improvements in health & safety to meet ever changing needs of the organizations and businesses.

There are many challenges in AI/ML implementation in mining industry, which need to be addressed for benefit of the industry. Implementing AI/ML in mines is more challenging than in most manufacturing plants. Nevertheless, operational excellence is possible, though it requires strategies for effective implementation and sustainability of new initiatives. Artificial intelligence (AI) and machine learning (ML), technologies transforming several segments, including mining. Many organizations have been implementing/developing AI/ML applications in mining. It has been helping to manage health, assets and resources in most optimal way.

AI/ML is in use in mining industry & operations. It's equally important to ensure the best usage of models through an innovative framework. One of the ways to improve usage could be, putting a metrics model/framework in place. In parallel, there is also an urgent necessity to having a culture of maintaining, refining, and using the models by practitioners, SMEs & management.

A strong metrics/measurement model/framework is essential for monitoring and tracking of AI/ML model usage in organizations. Furthermore, establishing a model-driven culture inside an organization is also required. This makes it possible for businesses to make better use of AI/ML models and get insightful information for making strategic decisions. A structured framework also helps in changing culture and help in embracing a new technology, processes, and systems. Encouraging an organizational culture that embraces technological advancement can help the organization in moving forward in right direction.

RESEARCH GAP:

There are many companies implementing AI/ML to improve organizational efficiency and effectiveness. AI/ML requires a systematic metrics / measurement-based system for accurate prediction and decision making. So, there is need to define a structured metrics model for better decision making through AI/ML in mining organizations.

Organisations, and researchers involved in the development and application of AI in mining, should prioritise their efforts to address model usage related concerns, ensuring that their AI systems are used effectively. This can be done by putting a metrics model for monitoring of usage of AI/ML systems.

METHODOLOGY:

For building the new metrics model/framework researcher opted to rely upon the secondary data available from the different industries. The researcher studied the existing processes & frameworks and its usage by the organizations.

We studied the safety and health issues of miner and mining sector, to get more insights into the real problems faced during mining operations. It was decided to focus on key measurements/metrics related to usage and monitoring of AI/ML applications used for better health of miners in open cast as well as underground mines. More importance is being given to measurements related to accuracy of models, business problem solved, instances of prevention of health issues & accidents etc.

METRICS MODEL FOR TRACKING THE USAGE OF AI/ML-BASED APPLICATION FOR HEALTH MONITORING OF MINES WORKERS:

Metrics model for AI/ML applications can be designed through a structured measurement Program. It will ensure better usage of Health Monitoring related AI/ML-applications in the organization.

The model will help in tracking the usage of AI/ML model/applications for health monitoring of mines workers including mining environment. It would track and monitor, Number of Health Workers and Users of AI/ML-Model / Application, Number of instances when model has predicted the health issues of workers correctly, Classification Accuracy of AI/ML model / application related to Worker's Health, Root Mean Square Error of AI/ML model/application related to Worker's Health, Average Sensitivity of AI/ML model/application related to Worker's Health, Number of business questions addressed by models related to Worker's Health, Number of departments adopted AI/ML model/application related to Worker's Health, Number of AI/ML model/application deployed in Health Monitoring of workers, Volume of Data Analysed during model usage for health monitoring, Number of time model predicted correctly and prevented Worker's Health Issues etc.

Below is the consolidated view of the metrics model:

METRICS MODEL TO ENSURE EFFECTIVE AND EFFICIENT USAGE OF AI/ML APPLICATION IN MINING FOR HEALTH MONITORING	Number of Health Workers and Users of AI/ML-Model / Application
	Number of instances when model has predicted the health issues of workers correctly
	Classification Accuracy of AI/ML-Model/Application related to Worker's Health
	Root Mean Square Error of AI/ML-Model/Application related to Worker's Health
	Mean Absolute Error of AI/ML-Model/Application related to Worker's Health
	Average Sensitivity of AI/ML-Model/Application related to Worker's Health
	Number of business questions addressed by models related to Worker's Health
	Number of departments adopted AI/ML-Model/Application related to Worker's Health
	Number AI/ML-Model/Application deployed in Health Monitoring of workers
	Volume of Data Analyzed during model usage for health monitoring
	Number of time Model predicted correctly and prevented Worker's Health Issues
	Number of time Model is being revised/recalibrated on the basis of output/prediction
	Number of time Model is being revised by addition of new health parameters
Number of time Model is used by executives for key decision making	

Mining companies can use this proposed framework with more customizations as per organizational needs and ensure more rigours monitoring of usage of AI/ML applications for miner's health and safety.

The framework can have positive business impact and result into benefits. Companies that excel at implementing such best practices throughout the organization will be in a better position in using AI/ML applications. It will allow companies to make more accurate decisions, improve health and safety, boost efficiency, and ensure sustainable operations.

To ensure the right use of models' procedures must also be established. Clear policies and procedures must be in place for better monitoring & tracking and continuous improvement.

LIMITATIONS:

The thorough examination of the difficulties associated with usage of artificial intelligence described in this paper highlights the significance of comprehending and resolving the implementation and usage concerns in the design of AI systems. Although the proposed framework will work as a useful manual for businesses looking to improve their usage, efficiency and dependability of AI systems. It has few limitations.

The proposed framework is created on the available literature and built based on the basis of limited information available. The framework needs to be validated by mining companies and model developers & practitioners.

CONCLUSION AND WAY FORWARD:

The proposed framework is being designed on the basis of current usage of AI/ML applications and related models in mining and allied industries. It will help management in the tracking of the effective usage of AI/ML technologies for health monitoring of miners. The framework and related data can also be helpful to health workers and authorities for better health management system in mining industries.

Implementation & Validation of this framework, followed by any adjustments would greatly benefit both further research and its practice in the mining sector. In future the framework can be enhanced by adding more best practices of other improvement frameworks like Balanced Score Card, CMMI, Six Sigma etc.

Although this research has offered a thorough review of the difficulties with usage of AI models in health monitoring, it has a number of drawbacks, which can be removed after more studies, research and inputs.

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