Mine Automation and Data Analytics

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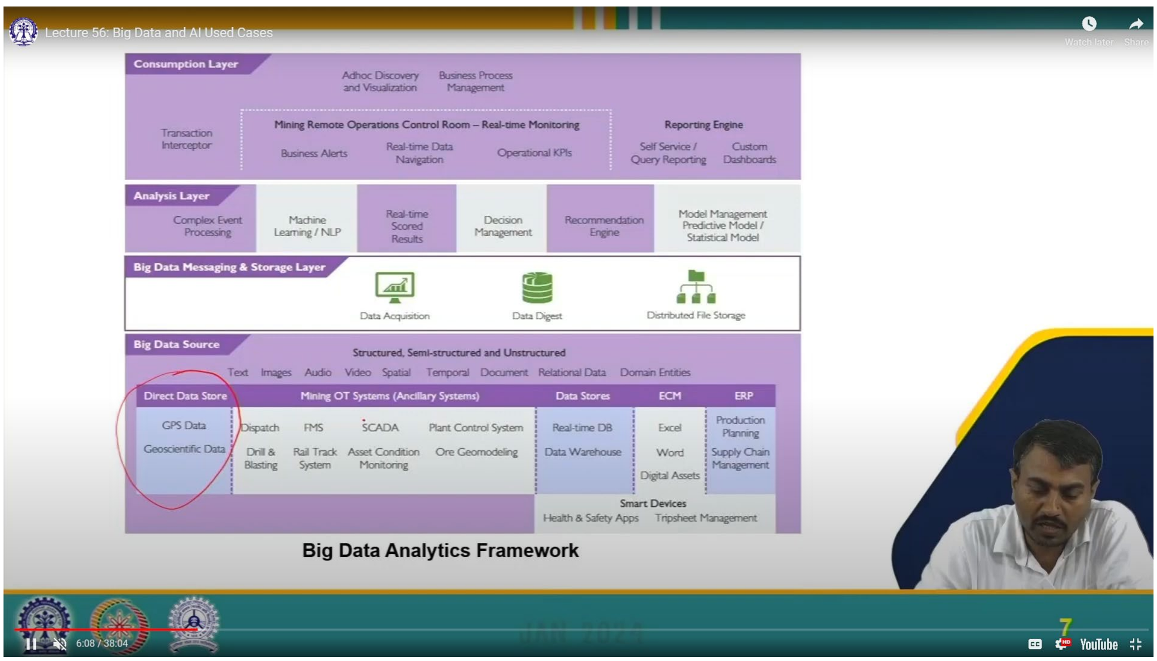
Week-12

Lecture-56

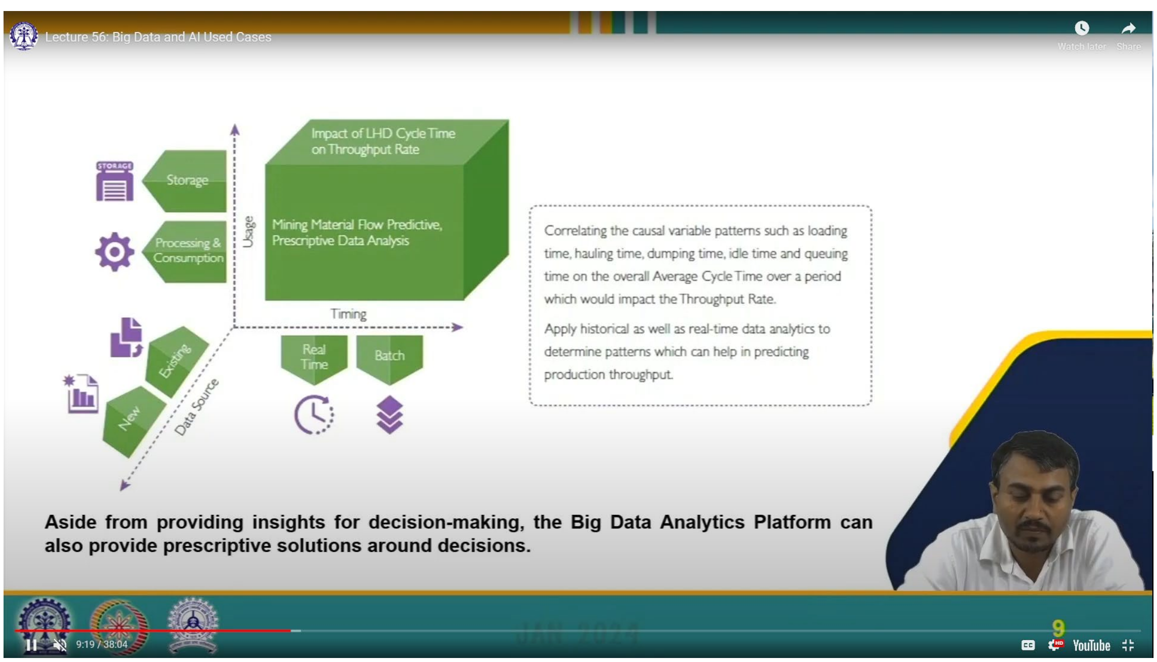
Big Data and AI Use Cases

Welcome back to my course. Mine automation and data analytics. Today, we will discuss big data and the use of AI in the mining industry. For the last few lectures, you have seen how the AI methodology and machine learning approach, different algorithms can be used, their merits and demerits. Today's lecture focuses primarily on the application side, exploring the specific areas where the mining unit's operations can integrate with the AI system, as well as the challenges that come with big data. That is basically the subject of today's discussion. So, today's lecture is mostly on big data analytics in mining, then different functions across the mining industry and associated big data analytics, then intervention across the mining process using big data, big data use cases in drilling, big data management (BDM), mining industry opportunities and future works, AI in the mining industry, levels of maturity in AI-enabled mining, benefits of AI, case studies, and the challenges in AI implementation.

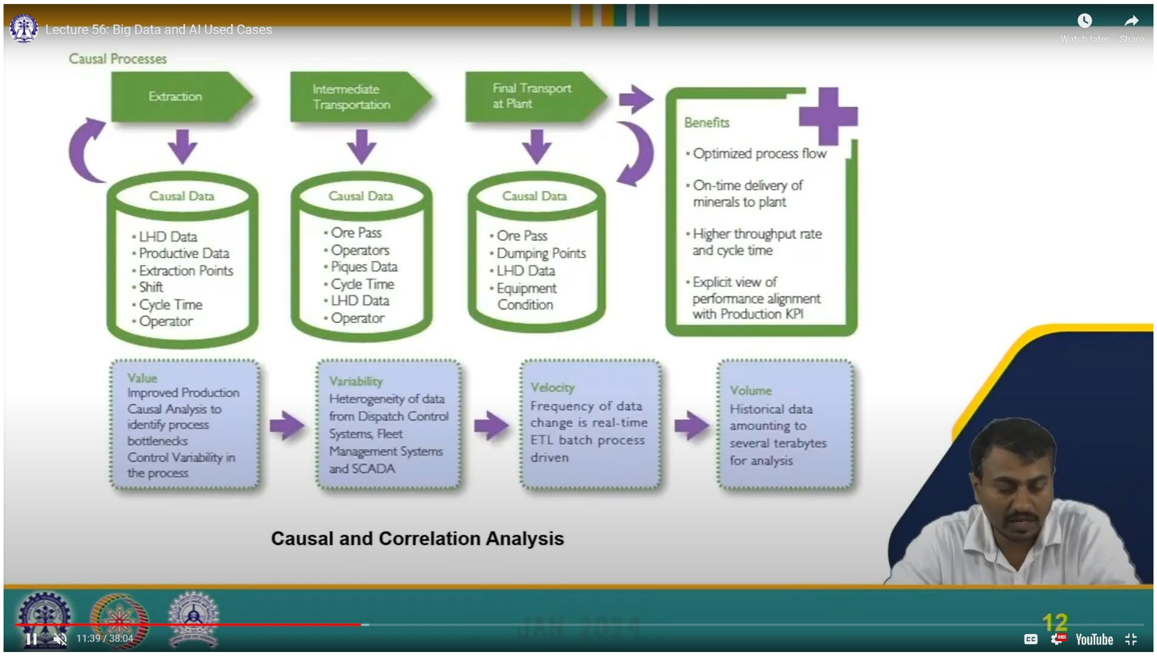
Let's discuss the application of big data analytics in the mining sector. As you know, with the concept of mining 4.0 advancing and many mining companies, many mining organizations are integrating big data sensor networks into their systems. So, it is gaining very important momentum now, and it will increase in the coming days as well. So, in different processes of mining, it has been observed its applications, and there are many potential advantages the companies are getting. So, this process is increasing, and the momentum is also increasing. This helps to maximize profit and asset utilization. So, this is the core business value chain that it helps to gain. So, companies are more inclined to use these methods to use a higher margin. So different parts of the mines and different sections of the mines are basically sensor-integrated. So, this sensor basically generates a huge amount of real-time data, a vast amount of data that also has some associated challenges that big data analytics basically handles. Across the mine, to implement this process and make it successful, companies are developing good networking systems, both Wi-Fi and wireless, with wired connections across the system, so that data can be streamlined and collected seamlessly without any intervention or without any problems or issues. There is a lot of heterogeneity in the data structure and also in the data format because different machines and different parts of the mine have different kinds of data, which basically makes the data more variable compared to other systems that have been used in big data analytics in other applications. So real-time predictive and prescriptive analytics are the main driving force behind the success of AI and big data analytics in mining. So, the data source in the mining industry may be direct or indirect. So, the direct measurement may be taken by the GPS or conventional geodetic surveys. Indirect data like SCADA, the fleet management system that operates in the mines, geo-modeling data, blast hole data—these are the indirect data, by-product data.



So, this particular picture shows, in a graph, the main framework of data analytics in mining. So here you can see the direct data stores, GPS data, and operational technology that operate in mining: FMS, SCADA, Real Track system, drill and blast, dispatch, plant control system, ore geo modeling, and asset condition monitoring. The data stores, real-time database, data warehouse, format, Excel, Word, digital assets, ERP, and other software to integrate all, as well as the smart devices, health and safety apps, and trip set management. So next, it basically comprises structured, semi-structured, and unstructured data in different formats: text, image, audio, video, spatial, temporal, all these kinds of data. Then it goes to the distributed file system, first the data digest, then the data distributed file system, and then the data acquisition. So, acquisition, big data digest, and the distributed file system. Then the analysis layer, so different levels of analysis have been done, and finally, at the final level, we are basically monitoring with business alerts, real-time data navigation, and operational key performance indicators (KPIs). So, this is basically the final dashboard in the data analytics framework. So, we have seen in the ore-core recovery how the geological pattern data is used to make real-time and right decisions in the mining process. So, these decision-making processes and the data we collect at different levels, if we analyze the data based on that, we can find out the lacunae, the problems, and the fault in the system. So, it will help us to use root cause analysis to implement the root cause analysis technique to find out the lacunae, the fault. So, for the next batch of processing, for the next processing stage, or for the for the next operation, we can basically overcome this kind of problem, or we can take certain kinds of remedial measures that will avoid or that will basically overcome these kinds of problems. So, these are the advantages.

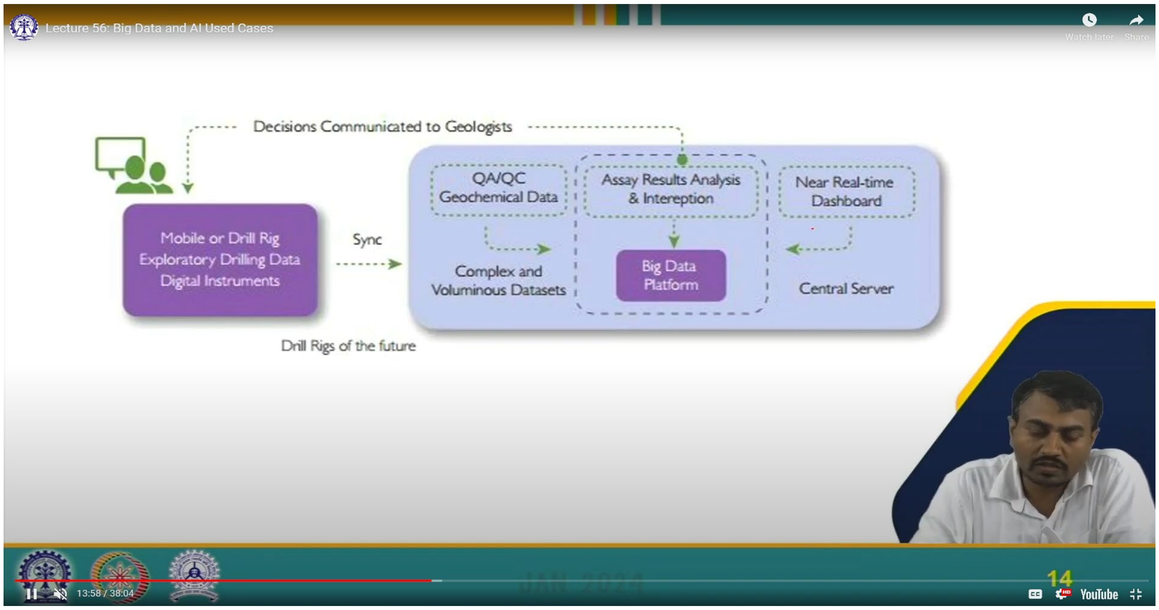


So here you can see that the LHD cycle time throughput rate is data, its time is real-time, and the batch and data source are new and existing; it is basically developing and the storage, processing, and consumption. If it has been plotted in three axes, it will show a kind of nice correlation of the data, and based on that, it can be found out that the throughput of the LHD cycle rate can be increased or improved based on these data analytics. So, applying these historical patterns, the data we found out, and the data we have stored from that data will help us navigate to the next stage of how we can improve the performance of these machines. So, this is basically the reason why we basically go for prescriptive solutions to reach a fruitful or profitable decision based on the historical data. So the material process flow basically comprises a big value chain that basically comprises the scheduled or unscheduled breakdowns of different machines that are associated with the transportation LHD structure. So, if these data are being collected sequentially and rigorously, we can use this data for prediction of performance, future prediction of performance, improving performance, and basically enhancing the efficiency of the system. So based on this, the daily level efficiency, the daily level production can be improved based on this analysis. So, the different techniques we can apply for that machine learning approach and the different statistical predictive maintenance approaches we can use will help us find out the causal relationship, the change, the fault, and the drawbacks, so that will help us overcome them to go to the next stage. So, the integration of the big data analytics platform is helping us to get a better and better advantage. So, the 3V we have discussed earlier now is the 4V, which is volume, velocity, variety, and variability. So, integrating all these will give us better efficiency and better optimization of the process chain.

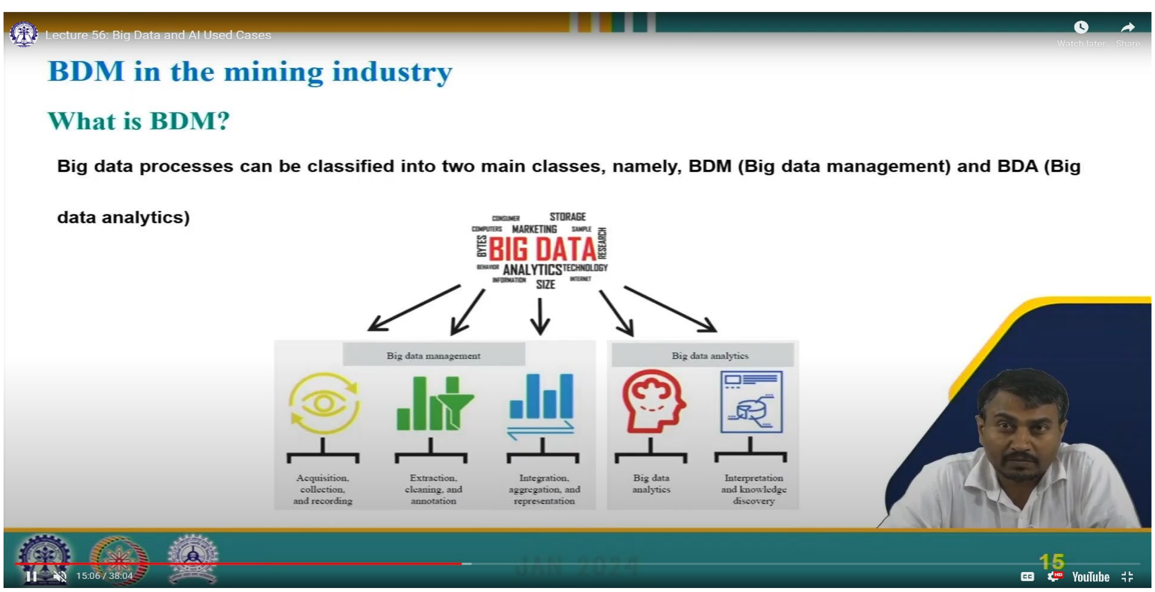


So, this is basically a causal correlation analysis. So here we can see the extraction of the mineral, so LHD data, productive data, extraction point, sieve, cycle time operator—these are the causal data. Now the intermediate transportation, so these need to be transported, so through ore pass, through operator, peak data, cycle time, LHD data operator. Now the final transport is at the plant, so ore passes, dumping points, and LHD data equipment conditions. So now we are basically integrating all these, so it basically gives an optimized process flow, one-time delivery of minerals to the plant, a higher throughput rate and cycle time, and an explicit view of the performance alignment with the production key performance indicator. So here, similarly, the value, the variability, the velocity, and the volume are associated. Volume is big because you are continuously collecting the data, velocity at what rate, mostly real time or near real time, and variability because of the heterogeneity of the data from different control stations and different control points, so dispatch control system, fleet management system, SCADA, so different data are there as well as the value. So, these data have good value to add to the process optimization.

So, the big data use cases in drills are that we will see that in the future, drill machines will be coming that will help, that will collect the data, that will process the data, that will process the sample in real time, and that will achieve good quality control.



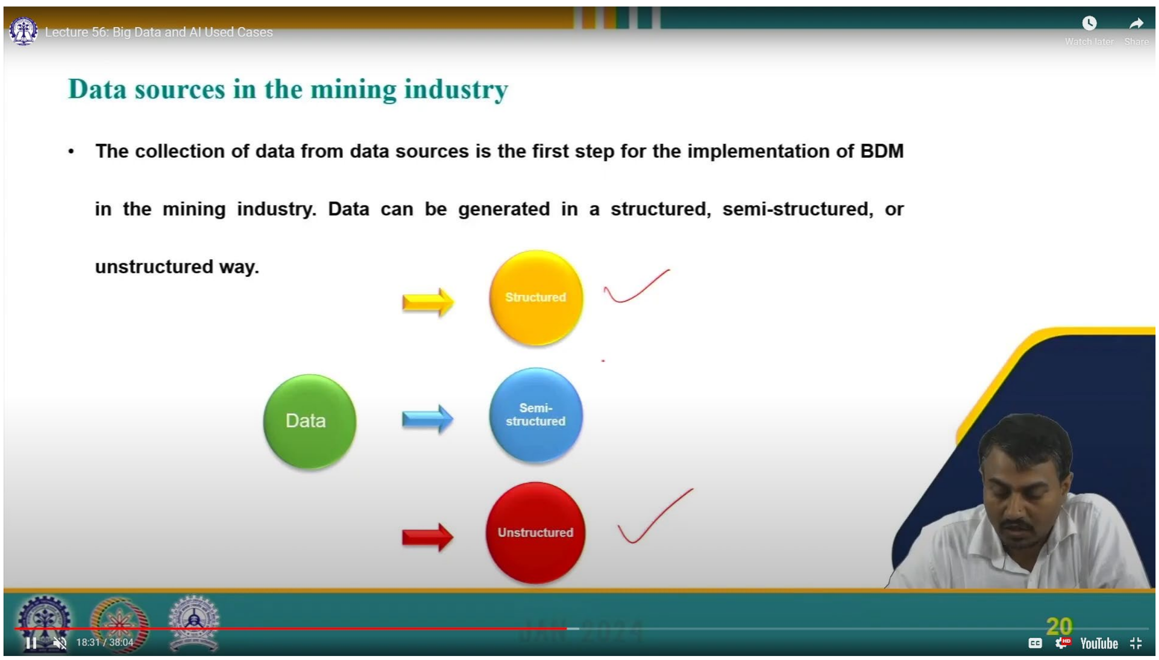
So here is the quality control of the geochemical data. This is a very complex and voluminous dataset, and as a result of analysis and interception, this is a big data platform with a near-real-time dashboard. So, it is always in communication with the geologist, so the mobile or drill rigs and exploratory drill data can be analyzed in real time, and this will help to develop a module that will give an instantaneous result at the field itself about the quality of the data, and based on that, we can reach a fruitful decision, a guided decision, or an evidence-based decision to optimize the process.



So, what is BDM in the mining industry? BDM is nothing but big data management. So before big data management, we have to collect the data, so the collection of the data, acquisition is also part of the BDM, extraction and cleaning are also part of the BDM, and integration, aggregation, and representation are also part of big data management. So big data management is the core, and based on that BDM, we basically go to the next stage, which is big data analytics, which is BDA. Here, we basically interpret, discover new patterns from the data, and help grow the business. So, the BDA primarily deals with collection, pre-processing, storage, and searing, which are the most essential parts of it, and the BDA is basically interpretation and knowledge discovery. So, both are basically complementary to each other, both are required, and primarily BDM is the prerequisite. So the BDM involves two main operations: big data storage and big data processing. So, at present, there are different file systems: distributed file systems and NOSQL database systems. So based on the priority, the availability, and the requirements, we have to select which kind of file system or which kind of data storage format we will follow. So, the DFS is a file system that stores data on a server, allowing client users to easily access and process data in a similar way as when stored locally. So, Hadoop DFS and Tachyon are two commercially available computing distributed file systems. So nowadays, the emerging NOSQL database is also coming with a higher advantage, overcoming the shortcomings of the DFS in terms of scalability, performance, and flexibility. So, the BDM basically focuses on parallel and distributed computation. So basically, we are using models like map reduction, map reduction, and a general-purpose GPU for processing the big data. So, MR, a distributed processing model proposed by Google, has two major advantages: hidden details and simplicity. So therefore, MR is widely employed by industry as well as academia. So, the direct acrylic graph DAG is a big data processing alternative to MR. So consecutive computation stages can be established in DAG, and the execution plan can be optimized. So, the DAG has been implemented in the Apache spark engines and is much faster than MR in disk resident and memory resident tasks.

Data source in the mining industry-So the collection of data is the first step in the implementation of BDM in the mining industry. So, data can be structured, semi-structured, or unstructured. We have already discussed that. So, the data is of three types:

structured, semi-structured, and unstructured. Structured data is the best one in terms of processing and analysis. Unstructured is the most difficult, but computers can understand. Semi-structured is a combination of it, and it comprises heterogeneous data sets or heterogeneity in the data format or data information. So, the structured data are often built on a deliberate structure, as follows for a particular scheme: So, they are usually well defined and predictable. Unstructured data have no structure that can be recognized by a computer and collected in a more natural way. Given that no predominant structure or hierarchy exists in unstructured data, the queuing and analysis of unstructured data are slower than those of structured data. Semi-structured data cannot



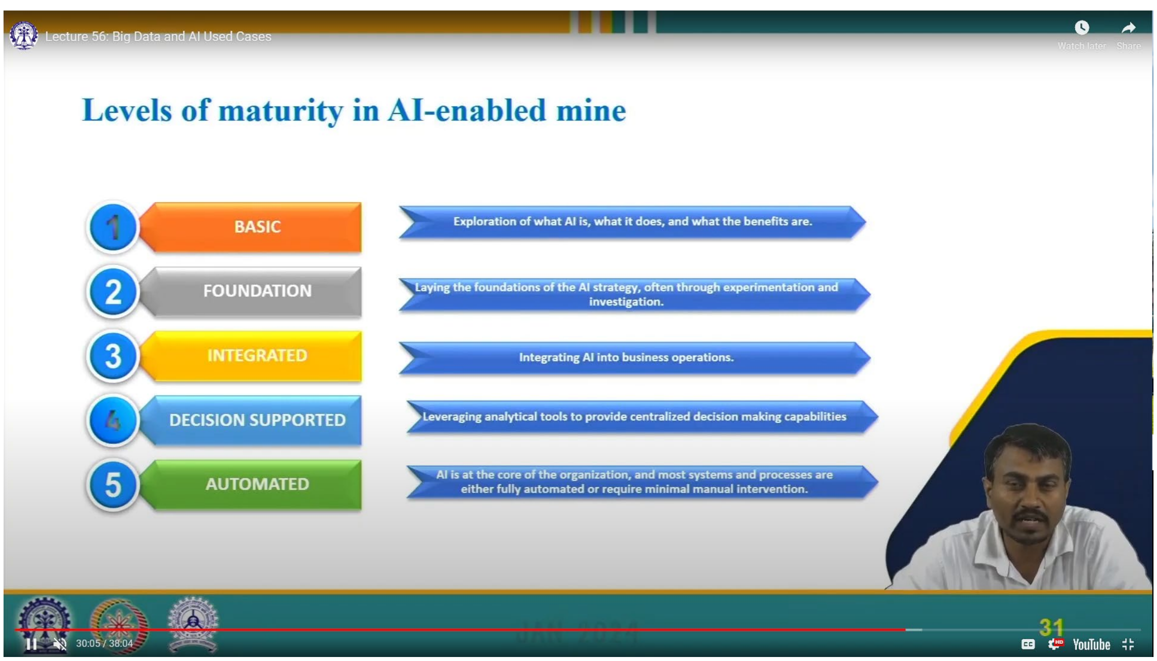
be arranged in a structured way if it contains certain information that can be recognized by a computer. Similar to the data types in other industries, the data types in the mining industry include text, audio, image, video, spatial, temporal, document, rational data, and domain entities. So, the data sources in the mining industry can be classified as direct or indirect data sources. So, the direct data sources, such as GPS, conventional measurement, and the field level using different machines or commodity price monitoring and different commodity prices that are in the market, are the direct data sources. Indirect data sources are basically by-product drill machines, operations, plant control, and rail track systems.

So, the direct data comprises the GPS, satellite, price, and geoscientific data on the mine site, for example. The indirect human, that is, the safety condition of the mine, the safety condition of the machines based on their performance, the working positions of different machines—these are the indirect human. Indirect asset, machine conditions, and equipment conditions are the indirect asset and the indirect process, drill and blasting, rail track system that is dispatch, conveyor, and the fleet management system. So, these are the major data sources for the mining industry.

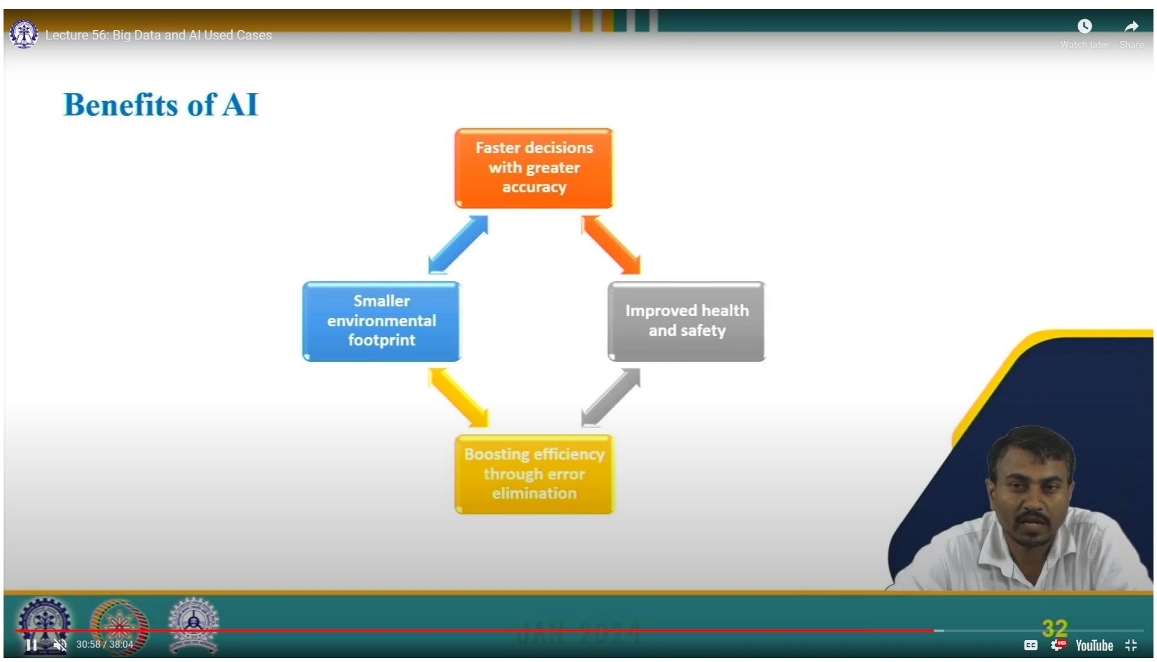
So, the opportunities and future work: So global database establishment is the first step in the storage, processing, and interpretation of big data in the mining industry. So, an ideal database project should have good extensibility and interoperability with other software. Moreover, it should be multinational, continuously updated, and highly accessible to all mining practitioners around the world. Because if mining professionals are not accessing it, if the practicing mining engineer does not access it, the problem associated with the protocol, the problem associated with the software, or the application will not be understood in greater detail. Until and unless it is applied to real cases, in different, different cases across the world. So, this is one of the important things that this kind of system should be available to all the working professionals in the mining industry. This would establish a good connection so that you can understand the lacunas, the fault, the improvement necessary, and the different firmware that is required on the software to upgrade it to the next version for better optimization. So, these are the requirements.

So Big data with an intelligent geological survey-So we are basically employing this technology, and the adoption of radio frequency identification was recognized at the frontiers in 2010.So nowadays, smart sensors and smart devices have generated a growing trend of increasingly big data production. So, these sensors cannot only capture data and information but also communicate or even collaborate on these tasks. So improved control and effective maintenance can be achieved with prediction and clustering through BDA.

Big data with cloud computing, the Internet of Things (IoT), and augmented reality: So, this can be, think of how big data, with the advent of the Internet of Things and augmented reality, can be worked together as different parts of the mining process chain. It can be implemented, and the application can be extended based on its availability and suitability so that we can harness the benefits of it. So, the cloud computing, which is the Internet paradigm, involves outsourcing data storage and computation to third-party data centers. It allows simultaneous access to cloud services by multiple users without an individual license. This is the major advantage. The IoT, the devices that connect to the Internet, often rely on 100 or 1000 smart sensors and devices. So IoT generates large data volumes while big data stores and analyzes them. AR is the emerging technology that enhances human perception by superimposing the virtual object on the real-life scenes, which improves efficiency, collaborates with experts, helps find faults, and makes the process more streamlined. So, AR offers promising visualization for complexity in big data applications in mining. Cloud computing, IoT, and AR accelerate big data adoption in mining, requiring new interactive platforms and methodologies. So let us focus on AI in the mining industry. So, machine learning and AI can be applied from the beginning of mining to the end of the mine life cycle. Starting from the exploration to the final product delivery, from prospecting to production to closer and mine reclamation. So, it has a wide range of applicability for AI in the mining industry. So compared to other industries, the mining and metals sector is considered to have a lower level of digital utilization. It is well understood why. The progress on machine and operation automation with intelligent technology development has been extremely slow. However, the mining industry is beginning to recognize and understand the importance of these fields and has recently started to explore the development and applicability of these technologies to enhance safety and productivity in mining operations. The mining leaders are turning to advanced technologies. This is a good sign, and they are trying to integrate different protocols, different developments in technology within the existing setup, or they are refurbishing the structure so that they can harness the benefits of it. So, this is a very good sign. So different machine learning approaches are used along with cognitive intelligence for getting better benefits, understanding the pattern of the data, and reaching an optimum solution. So, these technologies provide deeper insight and enhance image and speech recognition through deep learning neural networks. So, while no single technology can solve all industry challenges, AI-related technology integrated with workflows traditionally requiring human intelligence is enhancing organizational capacity. So, AI enables us to accomplish tasks efficiently, make decisions promptly, create and engage in interactions, and generate stronger business outcomes.



Level of maturity in AI enabled mine: The level one, basically helps to explore what AI can do, the benefits of mining, the pros and cons, and what should be done, so this is the basic level of AI. More so, it is a kind of reconnaissance. The second is the foundation, so laying the foundation of AI strategy often involves experimentation and investigations. So a small-scale pilot study is to be conducted to find out the advantages and efficiency that we are getting out of it with different kinds of changes in variable conditions that make the foundation that is level two. Level three, integrated. So now, after understanding it and using it, integrate AI with different parts of business operations. Level four: decision-supported leveraging analytical tools to provide centralized decision-making capabilities. So, this part we are working on is applicable here in the mining industry. So that an evidence-based, data-driven decision can be taken in real time, that will help to optimize our process to achieve better safety, reduce the cycle time in different operations, and increase the asset utilization of different parts across the mine. Finally, there is the automated. So now AI is at the core of the organization, and most systems and processes are either fully automated or require minimal manual intervention.



So, benefits of AI: So it helps to reach the decision with a higher speed and a high level of accuracy. Second, it improves health notions. It improves safety within the mine and within different operations that are carried out using different automated technology and AI-based decision-making processes. It boosts efficiency through error elimination, and finally, it makes a smaller footprint in terms of environmental damage to the environment. So, the new approach of AI is basically to limit the environmental footprint as small as possible so that we can work in the mine sustainably. So that we can sustainably make less damage, or we can design a kind of reclamation that helps to balance this damage so that we can run these operations parallelly without any further damage to the environment.

Faster decision with greater accuracy-So it helps to reach the decision with a higher speed and also with a high level of accuracy. So, the company RockMass Technologies is deploying advanced sensors to capture real-time data and identify potential failure planes on rock surfaces. Handheld hardware is used to analyze rock surfaces with software that analyzes data 18 times faster than the current manual methods.

Improved health and safety-It is basically based on the different observations and different sensors we are using and the different technology that we are using to help that a problematic situation is arising. So different sensors are to be fitted with the humans or the miners that also help to understand the situation of the miners, and by that, we can address different problems that the miners are facing at the mine site based on the data we are collecting. So, this basically helps to get better safety notions.

Boosting efficiency through error elimination-So company Ionic Engineering is utilizing the machine learning approach to significantly improve image recognition by identifying copper grades and drastically reducing the error compared to human efforts.

Improved health and safety- Company SHIFT Incorporation is basically using predictive energy peaks to facilitate automatic adjustment of the ventilation system through integrated process control.

So, let's focus on the case studies. The first case study is in the Tabaeksan Mineralized District of Korea. They basically use, firstly, the GIS software along with ANN, an artificial neural network, and logistic regression to find out the mineralization zone of gold and silver based on a limited amount of data. So, they trained the model, and finally they tested it with the new data, and they found a good solution. So based on this training, they found that this kind of algorithm, this kind of method, will give a better result, better optimization, and better predictability of the deposit of gold and silver based on this data. So similarly, many studies have been conducted to determine which algorithm to use. Here, they have used the ANN. So, they use the GIS software to plot which side of the district these minerals are deposited, and based on the new data, they predict with unseen data, which they match with the data, and they find good accuracy. So, they basically predicted where the gold and silver deposits might be in the district, and they found it very reliable and accurate. So, ANN software helps to compile, analyze, and visualize the geological data, and it was found that ANN, with its logistic sigmoid transfer function, proved effective for predicting and evaluating mineral potential maps.

Case study 2, the New South Wales of Australia. So, in this study, a neural network was trained to predict where gold deposits might be in a specific area and to analyze various types of data, like geological features and survey measurements. So, they also found good accuracy.

So let us find and discuss the challenge of implementing AI in the mine: One is the poor testing method used to generate insight. So, it is very difficult to gather consistently high-quality data to train models and generate actionable insight. Industry culture resists adopting AI-So leaders without a structured approach to innovations and potentially deficient in communication expertise or dedicated departments may struggle to seamlessly integrate AI into their corporate culture and operations. Integration with the existing system-Integrating an AI solution with an existing system, like an ERP system, can be complex and require careful planning.

So, these are the references. So let me summarize in a few sentences what we have covered. So, we have explored the applications of big data in mining. We have examined how big data analytics can be utilized in various sectors of mining. We have discussed intervention and optimization enabled by big data analytics across different mining value chains. We have investigated a specific use case of big data analytics in drilling operations within the mining industry. We have explored the strategies and methodologies for effectively managing big data in the mining sector. We have explored the opportunities and potential for future directions for leveraging big data analytics in the mining industry. We have explored AI in the mining sector. We have discussed different stages of AI adoption, implementation, and maturity. We have examined the advantages and positive impact of AI technology in mining. We have analyzed real-world examples and case studies showcasing the successful implementation of AI in mining. and finally, we have explored the obstacles and challenges associated with the implementation of AI in the mining industry. Thank you.