Mine Automation and Data Analytics

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IIT (ISM) Dhanbad

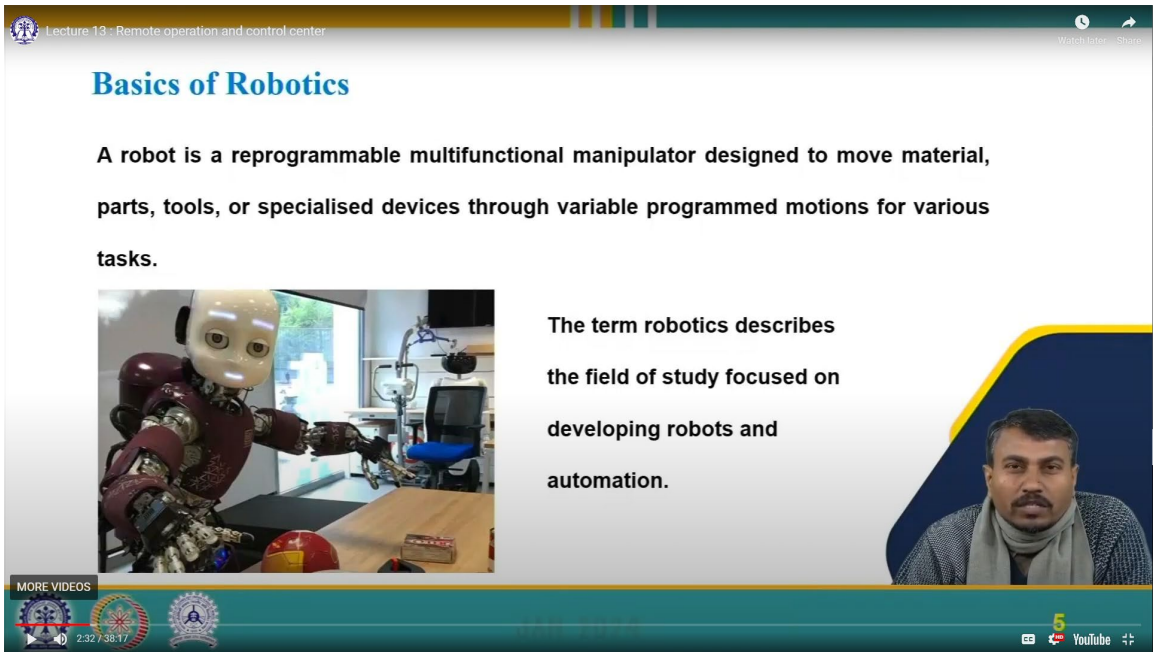
Week-3

Lecture-13

Remote operation and control center

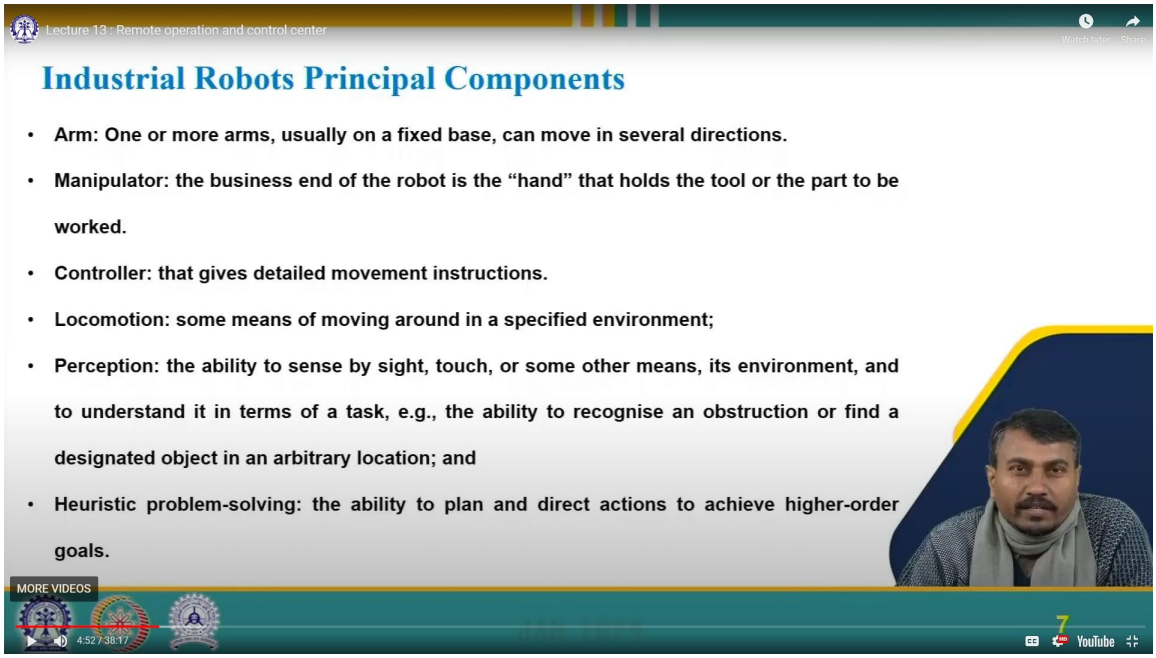
Welcome back to my course on Mine Automation and Data Analytics. So, in this lesson of remote operation and control center, we are going to cover the following concept: The basics of robotics, industrial robot principal components, then the role of robotics in the mining industry, then introduction to remote operation, modes in remote operations, remote operations centers, remote operations center implementation, integrated remote operation sensor that is IROC and central control room in mining, office Tele-remote, bench remote, a case study on remote operation.

So, let us discuss the basics of robotics. A robot is basically a device. The device is a programmable device with a multifunction manipulator designed to move material, parts, or tools or do some specialized jobs through various motions, and it completes various tasks successfully with a high level of efficiency.



This is a typical image of a humanoid robot. So, robotics is all about the study focused on the development of robots and developing automation systems for industrial use.

Industrial robots have principal components. There are a few components that are basically components of an industrial robot. Firstly, the arms; second, the manipulator; third, the controller; fourth, the locomotion; fifth, perception; and last, heuristic problem solving. So, all these components make a successful robot for the making task successful. Let us see what an arm is. It is one or more arms, usually on a fixed base, that can move in several directions. The manipulator, or the business end of the robot, is the hand that holds the tool or part of that work to be worked out.



Controller: it gives detailed movement instructions, including what to do, where to stop, how to do it, and everything else. Locomotion is all about movement in a specified direction in a designated area. Perception is the ability of the robot to sense by sight, touch, or some other means about its environment that surrounds it to understand it in terms of a task that is the ability to recognize an obstruction or find a designated object in an arbitrary location. And lastly, the heuristic problem-solving ability. It is the ability of the robot to plan and direct action to achieve fire order goals. Here, the robots basically analyze the system, make some decisions, and execute the work.

Role of robotics in the mining industry: Robotics plays a significant role in the mining industry, increasing efficiency, safety, and productivity. Deploying robots in mining operations can address various challenges and enhance overall performance. Here are some key aspects of the role of robotics in the mining industry.

Autonomous vehicles: drilling and blasting can be done by employing autonomous vehicles. So autonomous drilling and blasting systems can improve precision, reduce waste, and enhance safety by minimizing human exposure to hazardous environments.

Hall truck: autonomous hall trucks can transport materials within the mining site, optimizing logistics and reducing the risk of accidents.

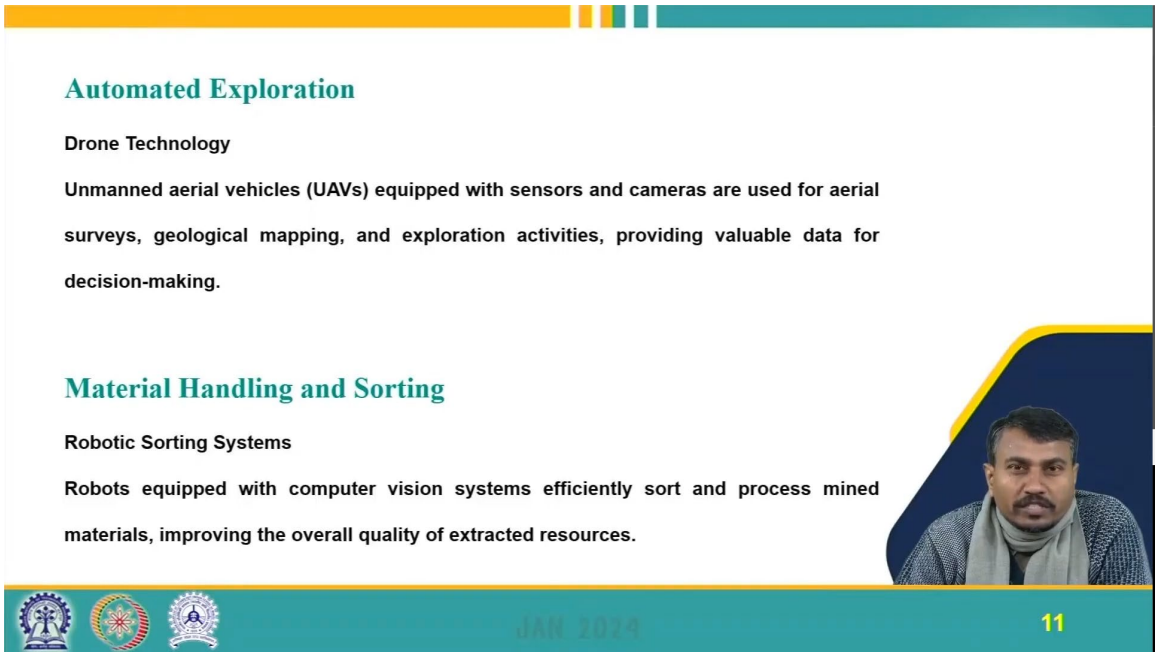
Let us discuss a question.

What are the primary characteristics of a robot?

A-fixed functionality, B-single-purpose manipulator, C-reprogrammable, and multifunctional, D-limited range of motion and E- lack of tool compatibility.

The right answer is option C: reprogrammable and multifunction.

Remote operation and monitoring. Through teleoperation, operators can control mining equipment remotely, allowing them to manage machinery in a safer environment away from potential hazards. Surveillance and infection. Robots can be used for remote monitoring and inspection of mining sites, ensuring compliance with safety regulations, and identifying potential issues and here are the robots being sensed using various sensing systems.



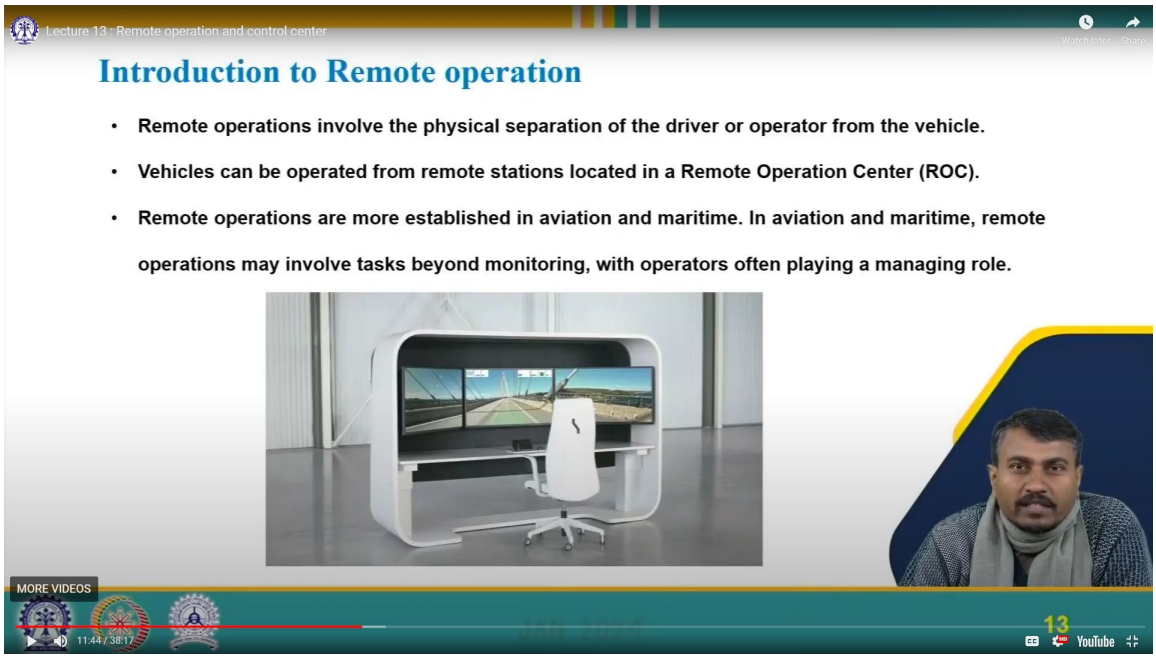
Automated exploration: drone technology/Unmanned aerial vehicles equipped with sensors and cameras are used for aerial surveys, geological mapping, and exploration activities, providing valuable data for decision-making.

Material handling and sorting-Robotic sorting system: Robots equipped with computer vision systems and cameras efficiently sort and process mined material, improving the overall quality of extracted resources.

Data analytics and predictive maintenance- Sensors and IoT devices: Integration of sensors and Internet of Things devices on mining equipment allows for real-time data collection, enabling predictive maintenance strategies and reducing downtime.

Safety improvement-Robotic rescue system: In emergencies, robots can be deployed for search and rescue operations, minimizing the risk to human rescuers. This is one of the very important aspects of the deployment of robots in mining because during emergencies and more particularly under extreme conditions, such as an underground if a concentration of noxious gas is used, we cannot permit the movement of a human rescuer without any safety devices. So, under these circumstances, a mobile portable robot can be deployed that has the crawling efficiency to move in dynamic and rough terrain and can get very useful data that might be useful for the rescue operation in those conditions.

Introduction to remote operation. Remote operations involve the physical separation of the driver or operator from the vehicle, and the vehicle can be operated from remote stations located in a remote operation center (ROC).

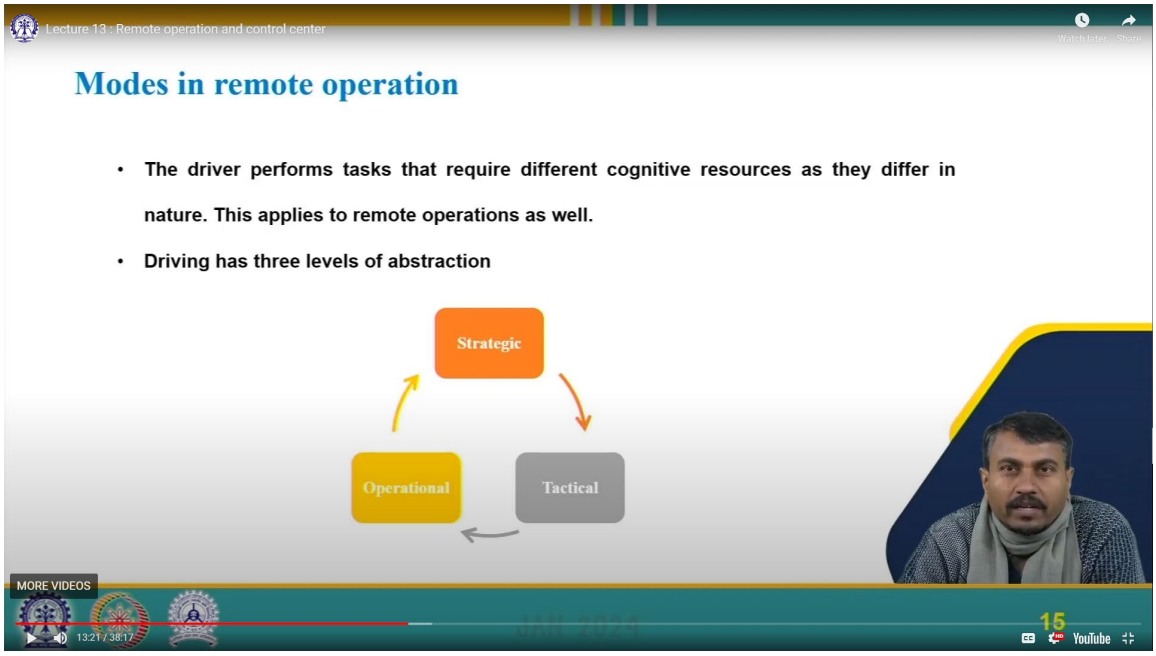


Remote operations are more established in aviation and maritime. In aviation and maritime, remote operations may involve tasks beyond monitoring, with operators often playing a managing role. This is a typical example. The remote operation center may be situated in a distant location, and it operates and controls the activities from a faraway distance. The expansion of remote operations is beneficial, as it is likely that human involvement will be needed even in fully autonomous vehicles.

In ground-based traffic and road freight, remote operations are a relatively new concept. Operators primarily monitor and support the dynamic driving task when necessary in

these domains. Examples of remote operations include the remote air traffic control tower (ATC-TS) where control officials manage air traffic within designated airport areas from a geographically separate location.

Modes of remote operation: The driver performs tasks that require different cognitive resources as they differ in nature. This applies to remote operations as well. Driving has three levels of abstraction. Strategic, tactical, and operational. So strategic, tactical, and operational are working continuously to enable autonomous driving and make it successful.



Strategic level of operation:

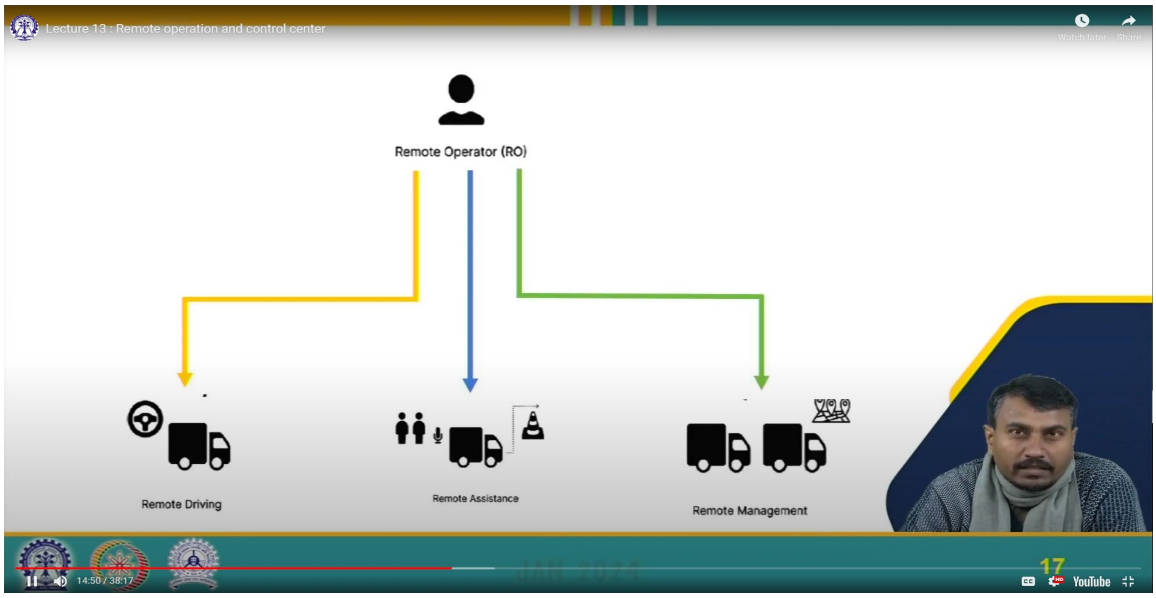
The strategic level involves route planning as well as cost and risk considerations. This is the most vital part.

Tactical level: The tactical level is conscious and intentional and includes driver decisions such as when to overtake another vehicle under certain conditions.

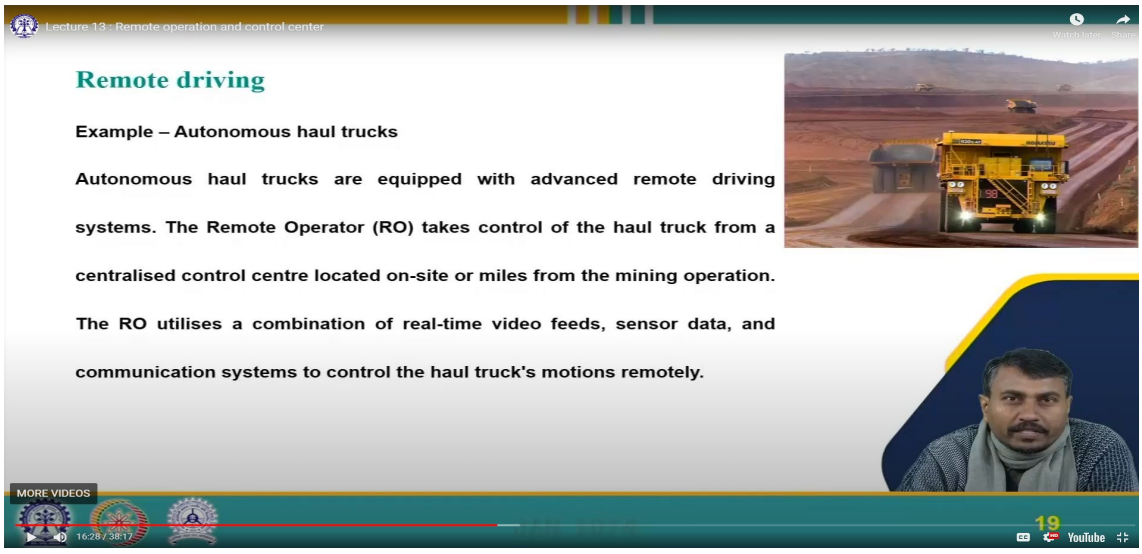
Operational level. The operational level implements the decisions made at a tactical level and therefore includes simpler operations such as steering, accelerating, or braking based on the situation of when to apply the brake or when to accelerate the vehicle. Remote operations involve remote driving, remote assistance, and remote management. So remote operators have a multi-purpose role in achieving control over the system.

Remote driving: Remote driving, or sometimes remote control, is when the entire or part of the dynamic driving task (DDT) as well as fallbacks are performed by the remote operator.

The remote operator thus controls the motion of the vehicle, and while that is ongoing, It cannot be considered to be autonomous driving. Remote driving is thus related to a tactical and operational level of abstraction. Example: autonomous haul trucks. This is a typical example of an autonomous haul truck operating in an open-pit mine.



The autonomous haul trucks are equipped with advanced remote driving systems. The remote operator takes control of the haul truck from a centralized control center located on site or miles from the mining operations. The remote operator utilizes a combination of real-time video feeds, sensor data, and communication systems to control the haul truck's motion remotely. This is a very good development in the mining industry, and by utilizing this kind of autonomous haul truck mining, we are operating with a very high level of productivity as well as a high level of safety and efficiency.



Remote assistance: Remote assistance does not imply that the remote operator performs the dynamic driving task DDT or any fallback. Instead, consider the goals and tasks that the automated driving system ADS should accomplish and facilitate trip contribution in situations where the ADS needs additional input. For example, by putting out way points to aid decision-making when overtaking an obstruction. These tasks are related to the tactical and some extinct strategic levels of abstraction.

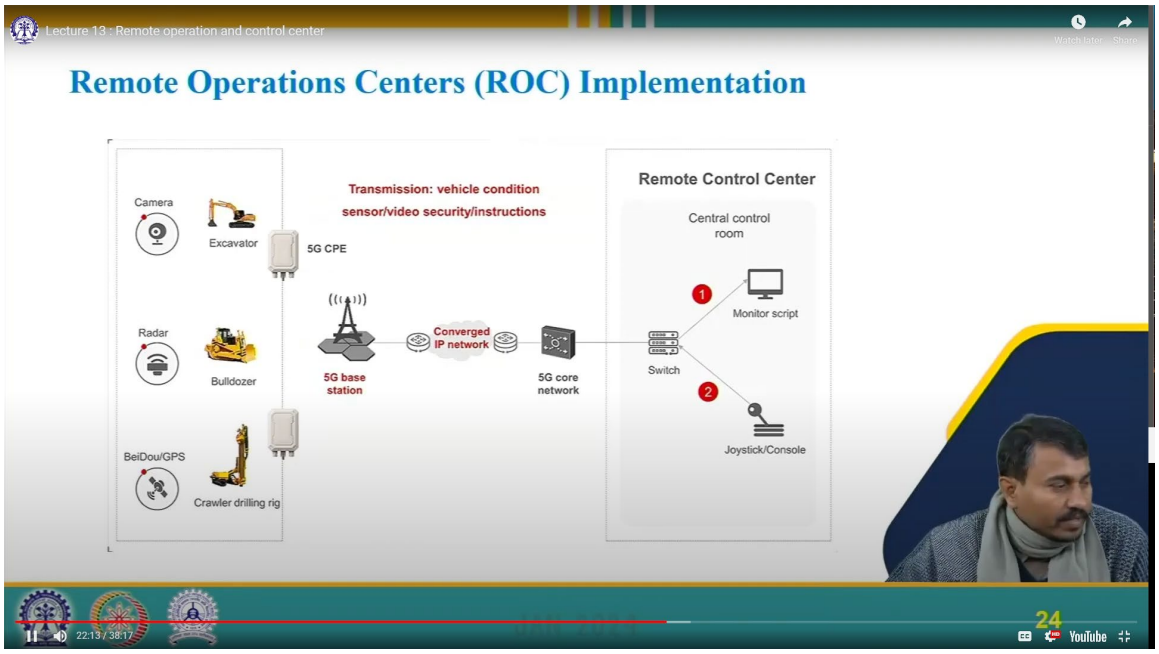
Remote operation centers: A remote operation center enables supervision, control, analysis, and data acquisition from a faraway distance. In the simplest terms, an ROC can be regarded as a platform for enabling process automation and business integration. The ROC enables the following: It enhances occupational health and safety by removing operators and maintainers from risk exposure. That is one of the big advantages, and that is why all mining companies are looking at remote operation centers to reduce hazards and fatalities in the mines.

It also reduces labor costs by relocating high-cost, knowledge-intensive labor away from mine sites to urban centers. It increases productivity through the following: It identifies the inefficiencies at the operating interface. That is one of the key advantages of the remote operation centers because they have a data backup, and by analyzing the data, they can identify the points of inefficiency at the operation interfaces. Through collaborative planning between functions in operations maintenance and procurement, all things can be done continuously with one another, maintaining the chains of activities, and that can be achieved by the remote operation centers

Sharing of experience and knowledge across mine sites, and that is also the key advantage that experience is shared so that the other operators also get the same exposure and knowledge and can also operate with a higher level of efficiency. Process visibility along the process chain. The status and progress of all the processes are visible at all the process points. So that is also the key advantage, and by doing so, it also enhances productivity. Its potential to lock in benefits through knowledge capture and reuse is also a great advantage of remote operation centers.

Remote operation centers (ROC) implementation:

Implementing a remote operation center ROC provides an essential catalyst for change in the organization. Current workflow patterns must be evaluated, modified, or adopted to make the remote operation center successful. Implementing ROCs therefore provides a necessary stimulus for changing work practices and driving an organization to achieve higher labor productivity. Interest in applying the ROC is growing within the mining industry, which is also a very good point for this kind of technology coming in a big way in the mining industry.



This is the typical framework for how the remote operation centers work at the mine site. On the left side, we have different sensing systems: the cameras, the radar, and different sensing systems like GPS or GNSS that are mounted with the different instruments that operate on a mine site. For example, here are the drilling rigs, bulldozers, and excavators. So these machines operate at the site level at the mine site. Now we need to establish a connection with these devices, and we also need real-time data about the environments in which these machines operate.

So we need the sensor data from the camera, we need the location data from the GNSS, we need whether there is any obstacle in front of it, and we need the radar data. So how do we get the data? We can get the data through the network. Here is the 5G CPE: This 5G CPE provides data communication between the machine and the nearby control center. So through this 5G CPE system or 5G network system, the transmission of the data is enabled, and by that data from the control station, we get the real-time data of the camera and the real-time data of the GPS so that we can assess the location of the machine and the surrounding environment near the machine.

So to enable that facility we need to install 5G base station nearby or near the mine site so that this network is available all through the mines at all locations of the mines and there would be some converged IP network systems and the 5G core network system that will be connected with the switches and some control systems and here also we have to keep in mind the security of the data so that this data cannot be tapped by other agency or third party and that the data transmitted through the 5G network is visible at the central control room in the monitor and also based on the necessity here from the control room we also give the command and that command is also gone through the same network to the

machine that some work to be complete or some work to be accomplished. So here also, it is a two-way connection; data is coming through the network system, and some commands are also going through the same network system. So this is the way the remote operation centers are working at the mine site. So the key aspect is the network system, so we need a very high level of network system that has a very high bandwidth so that large data can be transmitted instantaneously and so that establishing control over the system can be established very well and efficiently.

Integrated remote operation centers and central control rooms in mining:

So by establishing a centralized control room, seamless monitoring and control of various essential equipment across multiple mines, mills, smelters, and power plants become possible. This centralized approach facilitates the recording and analysis of a substantial volume of processing variables. These variables are transmitted from locations kilometers away, enabling effective remote monitoring. So this is the typical picture of an integrated remote operation center that operates a few mines together from one location. Moreover, integrating advanced predictive and prescriptive analytics enhances the overall operational efficiency and decision-making processes within the mining, milling, smelting, and power generation facilities.

Control rooms allow you to monitor, operate, and control existing equipment and auxiliary facilities. Data, verbal information, radio signals, video images, and satellite messages will be transmitted and centrally collected. This information can be fed into the customer's operating network or provided to other users. Mine operators have a complete

overview of the mining sites at all times, and they can determine who else can receive the information.

Design of the control room: The control room operators actions directly impact uptime, production output, quality, and safety. A poorly planned and designed control room can lead to costly mistakes that can directly impact human error. So here, a good design and a good system are very essential.

Question number 2.

What functions are performed in control rooms according to the descriptions?

A. Limited to data monitoring, B. solely data collection, C. monitoring, operating, and controlling equipment and auxiliary facilities, D. transmitting verbal information only, E. Controlling new equipment installations.

The right answer is option C. Monitoring, operating, and controlling equipment and auxiliary facilities.

Functions of the control room:

The application of a multifunctional open system is an essential element in the design of a control room. All installed devices are compatible with the Ethernet and TCP IP protocols.

The system separates process control from the management level, guaranteeing a stable and safe function. Figures can be displayed on either a full screen or a diminished window, or they can be transferred to a large-screen monitor. Installing a central control station can cut costs by optimizing the workforce. The control center only requires two people, so you can allocate workers in other areas. Reducing maintenance problems is recognized early before they can cause severe damage reducing administration support.

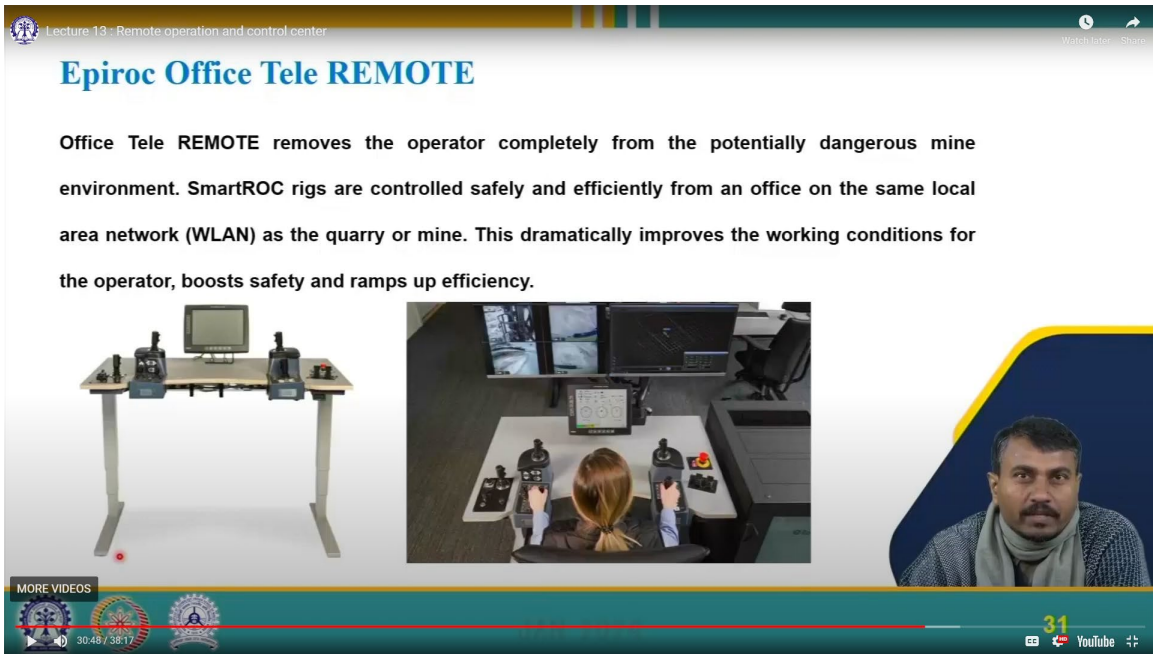
Epiroc office is tele-remote:

Office tele-remote removes the operator completely from the potentially dangerous mine environment. SmartROC rigs are controlled safely and efficiently from an office on the same local area network as the query or mine. This dramatically improves the working conditions for operators, boosts safety, and ramps up efficiency.

This is an example of the Epiroc office tele-remote system.

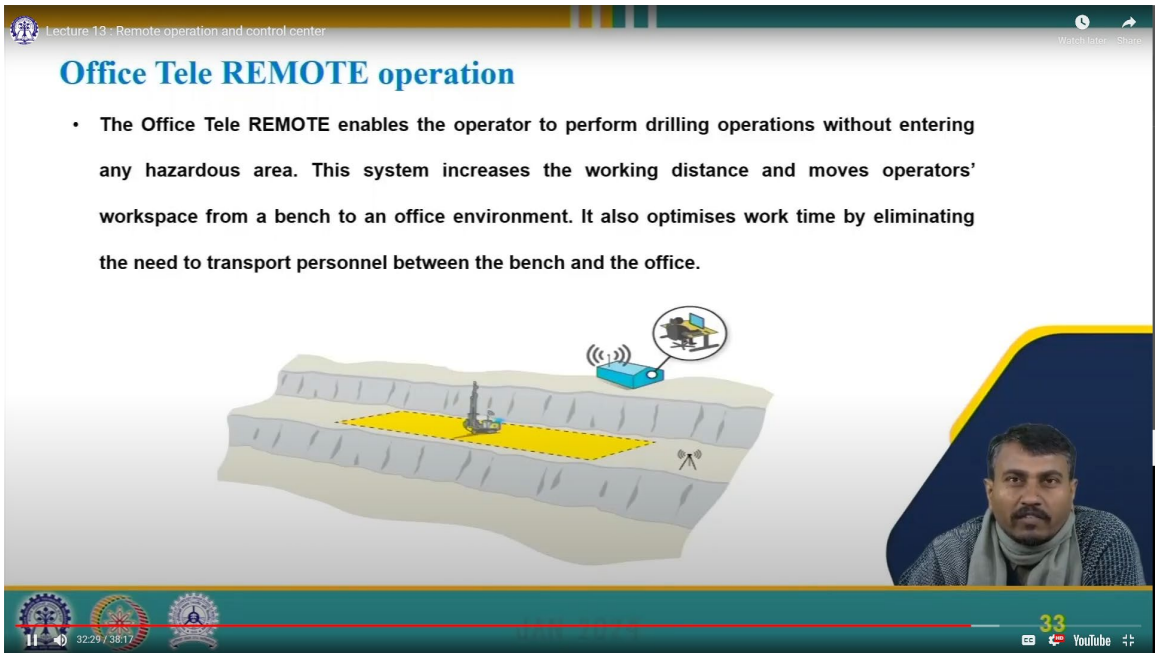
Benefits:

Enhance safety: Mines and quarries can be dangerous places. The office tele-remote removes the operator from the worksite, drastically increasing safety,



Improved working conditions for operators: SmartROC rigs operators can sit together in the office control center away from noise, danger, and dust.

Increase utilization, productivity, and efficiency: Each office tele-remote controls a single smart ROC rigs as standard, with the option of extending to nine machines using the same server rack. This represents a massive increase in equipment utilization and return on investment for each rig.



Office tele-remote operation: The office tele-remote enables the operator to perform drilling operations without entering any hazardous areas. This system increases the working distance and moves the operator's workspace from a bench to an office environment. It also optimizes work time by eliminating the need to transport personnel between the bench and the office. So this is the typical image of the office tele-remote operation from the center.

The office tele-remote system comes with built-in scalability. In its standard form, one operator runs a single smart ROCD. However, this capability can be extended to nine machines. Also, being part of the same infrastructure makes network management more accessible and helps overcome network congestion when operating drill rigs with other equipment in exact locations. So here, simultaneously, a few drill rigs are operated from the same center. If a site is already operating a bench remote, an upgrade is available to move it into the office control center.

It can work side by side with an office tele-remote as well.

Atlas Copco bench remote:

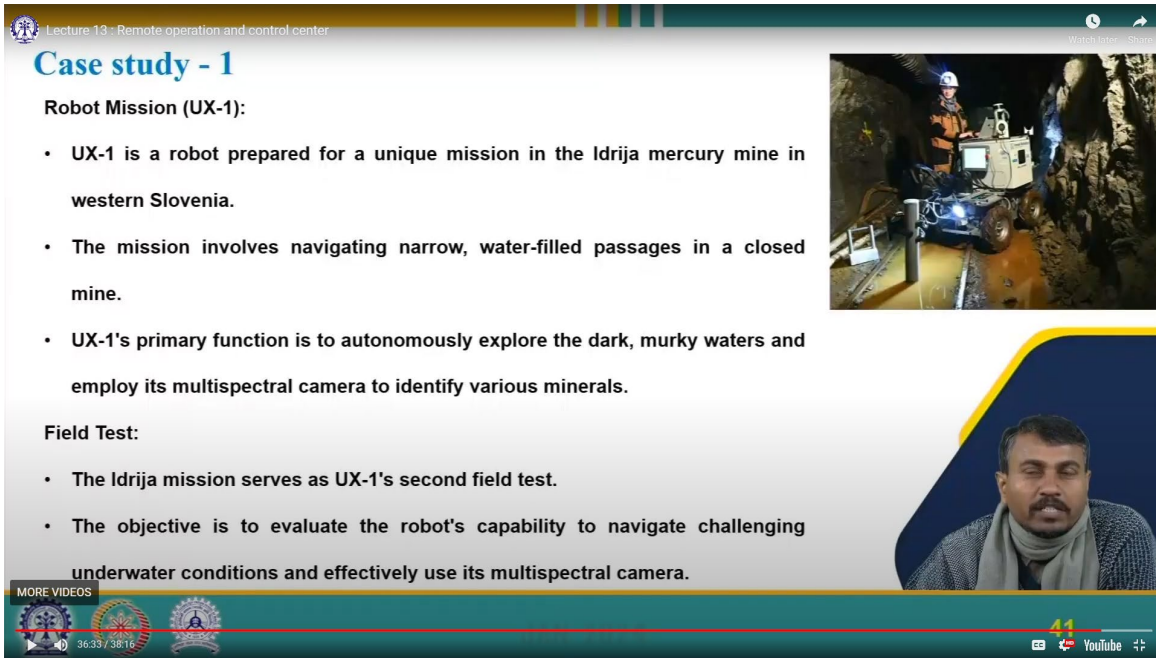
The bench remote is a unique operator station for all smart ROCD 65 rigs that enables operators to do their job from a safe distance. Bench remotes can handle one rig and up to three rigs in parallel. This takes productivity to a new level. Main benefits: productivity-Increase operator efficiency with multitasking capability. You can operate up to three Atlas Copco smart ROCD 65 rigs from one operator station. Safety. Get away from the unstable, hazardous benches. Drill close to the wall without having to enter the drilling area. Working conditions-With reduced noise and dust levels, bench remotes make surface mining operations a safe pleasure. Working together with other rig operators also makes the work more enjoyable.

Bench remote operation: Bench remotes can be used up to 100 meters from the drill rigs and 30 meters above the rigs, which means that you can be productive without having to enter a hazardous area.

The operator station can be installed in a vehicle, trailer, or container, and all controls and screens are the same as in the actual rig cabin. Here, from a wheel or from a vehicle, the control is established, and the same operation is done remotely from a safe distance away. This provides secure wireless network communication between the operator station and drill rigs.

Let us discuss one case study. This is a robot mission. UX-1. This robot was developed through collaboration between the industry and academia. UX-1 is a robot prepared for a unique mission in the Idrija mercury mine in western Slovenia. The mission involves navigating a narrow water field passage in a closed mine. The UX-1's primary function is

to autonomously explore dark, murky waters and employ its multispectral camera to identify various minerals.



The field test has already been done. So, the Idrija mission serves the UX-1 second field test. The objective is to evaluate the robot's capabilities to navigate challenging underwater conditions and effectively use its multispectral image. This UX-1 is working properly even at a depth of 19 meters from the surface with a water level of 19 meters, which means that from the water level 19 meters below, it is working properly under very dark and murky water conditions.

These are the references. So let us conclude in a few sentences. We have introduced a fundamental concept related to robotics. We have explored the vital components that constitute industrial robots. We have examined the application and significance of robotics in the mining sector. We have defined remote operations and their relevance in industrial settings.

We have explored different operational modes in a remote setting. We have introduced the concept of remote operation centers. We have explored the process and considerations involved in establishing remote operation centers. We have examined the centralized control setup for remote operations in mining. We have discussed specific remote operations of EPIROC, Office Tele-remote, and Atlas-Copco Bench Remote. We have examined a real-world case study illustrating the implementation and outcomes of remote operations. Thank you.