

Mine Automation and Data Analytics

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Week-4

Lecture-19

Introduction to Geo-fencing

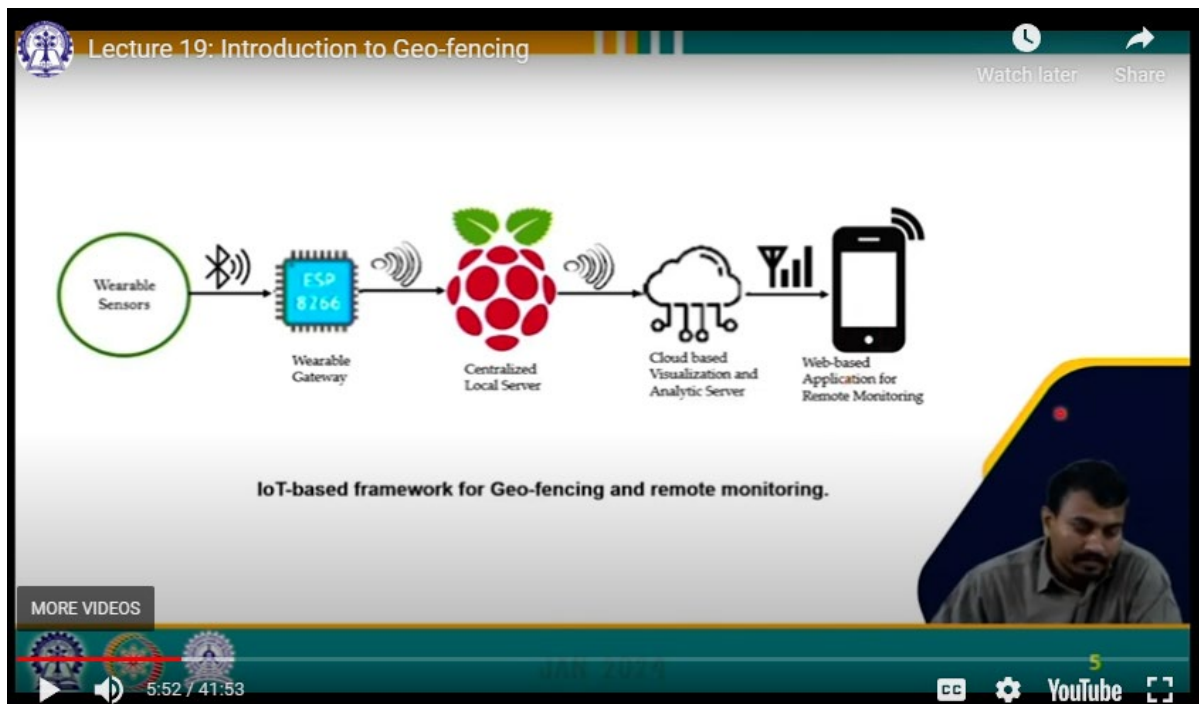
Welcome back to my course, Mine Automation and Data Analytics. Today, we will discuss on the geofencing technology that is used in the mines for getting a better control over different equipments that is operates in an automated mines.

So, in this lesson, we will cover the following: the introduction about the geofencing technology the implementation of geofencing in different mine site, and the different algorithms that has been developed since 1970s about efficient optimisations on this process. Then, how geofencing keeps the miner safe and, how to track the miners and the geofencing applications and geofencing application in the mining industry, and the key features of geofencing for the mining industry.

So, geofencing is basically a framework basically location-based framework or location-based service that enables a detection of movements of vehicles or detection of movements of mobile devices or equipments for a particular periphery or a defined periphery whenever it enters, whenever it leaves, whenever it crosses, whenever it bypass that but that particular periphery so it will it will create a database it will create the alert it will it will alarm and it will our the alert system to the user and to the supervisor and this whole technology is basically the geofencing. So in the 1970s, this is basically developed because of the supply chain management issues, and later on, to solve these issues, particularly the location based service the, computational geometry came into the picture because different areas are not very homogeneous, not specifically circle or elliptical or any polygon like that so there is a necessity of exactly detecting whether the point is inside the polygon or point is outside the polygon so based on that there are different algorithms different mathematical framework also developed.

So, this is basically a schematic diagram of the geofencing system here we are try to focus that this geofencing system is the sensor is with the device okay or with the equipments or maybe when we are thinking of implementing this geofencing technology for tracking the miners okay so some wearable sensors might be there with the miners so that is connected through network to the wearable gateway so this gateway is basically ensure that there are some resource sharing within the network one and these gateways also helps to make sure that there is no unauthorized attempt from the outer sources and by that it ensure a seamless network connection with the connected device so this is basically this gateway is efficiently utilized for making this system very safe then that is connected to the centralized local server sometimes these server basically process all these data and that is why sometimes this is been installed in a particular station and that basically available on the cloud through the network and through that cloud we basically give access to different devices particularly in operations we need to provide this kind of information to the supervisor to the worker sometimes so that those are the authorized person can get the information about the process that process is going on and

that process is implemented through the geofencing technology their status through these devices IOT based devices or mobile devices or industrial gadgets.



So, a geofence can be dynamically generated like a circular area surrounding the current position of a mobile device or can be made of a predefined set of boundaries which may be arbitrarily drawn by the user or specific for a place or a building and also based on the necessity of a particular operation so geofencing service can be classified depending on the geographical references used to check the device position in static check the geographical position of a mobile device with respect to a fixed area and the dynamic operates according to the position of a mobile device with respect to a changing area and peer-to-peer that uses the geographical position of a mobile device with respect to other mobile devices.

So, the geofencing implementation so one of the major component of this geofencing system is basically the location monitoring unit LMU which is the component integrated in the geo system and geofencing system infrastructure and that is responsible for location processing of the position of a mobile device and for keeping the geofence scenarios active so this geofencing system is can be operated in a mobile based system or it can operate with a centralized system so there are some advantage of mobile based system as well as the centralized system so based on the specific needs and the specific feature of a particular site we may go for the one technology that is more suitable.

Mobile based geofencing system it works basically using the satellite. GPS technology to find its position and checks it against a set of geofences right on the devices because geofences is basically some logic logical parameters that is defined on a geographic area and there are some key features of it this approach is likely having a smart device you need a mobile gadget or Android device that does most of the work itself so it is a very lightweight geofencing system and also cost-effective and the consideration is it's good for ensuring trust with the node positions but can use a lot of battery due to the device doing the geospatial processing because smaller devices does the everything so battery consumption is an issue so for a small operations this kind of system might be a very good system.

Centralized geofencing system, it works basically using a network infrastructure and the position matching is done with the geofences through the server that is installed in the geofencing system network so here network does the everything and the server does the everything and the device is basically connected through the network so device is not processing the data server is processing the data and that is retreating back to the device so all the heavy processing is done by the centralized server and making it potentially more efficient for the mobile device and this could be a good choice when we want to minimize the impact on the mobile device battery.

So, here we try to focus some of the features of the geofencing technology one is the location accuracy so location accuracy is an important component here different geofencing system provides a few milli a few meter accuracy to a sub meter accuracy as well so geofencing accuracy is strictly related to the accuracy of the geographical position provided by this service used to track the location of mobile device either satellite GPS or GSM based systems and the services tracking rate it expressed the frequency by which the device provides a location update to the server of the proactive location based system LBS device speed is also an important component here how this basically basically at what period it basically update the location informations to the eligible events eligible devices and eligible process so this basically determines the process cycle time as well the device route the path is basically the device takes across the geofence area affecting the period within which location update must occur okay and the last is basically the geo notification delivery this is very important component and geo notification can be delivered to the user only once or every time the mobile device successfully enters leaves cross or bypass a geofence area so based on the algorithm it may issue the alert once or it may issue the alert every time so that is basically depends on how the design is done on this particular algorithm.

Geo-fencing algorithm so as I said that this particular problem is basically address from the geometric point of view and later the computational geometry and one of the most important and popular method is point in polygon test in abbreviation PIP so it is a geometric algorithm used to determine whether a given point lies inside or outside a polygon or a very close to the polygon boundary so sometimes in many algorithms they use some epsilon error so epsilon is the is the limit that if epsilon limit is basically closing so it can say that it is very close to the boundary like that so this test is commonly employed in various application including geofencing algorithm and the GIS geographic information system the fundamental idea is to check whether a specific points coordinate fall within the boundaries of a polygon for sensitive cases as I already told there are some algorithm that basically checks the Delta amount or epsilon amount that is basically the tolerance of this particular system so this can be well understood so this is basically an area so this is basically a polygonal area and very very not regular so suppose here it is the point so this technology is called ray tracing so a ray passing through these particular boundary how many times it basically crosses the boundary the edge that basically defined by the numbers so there are some algorithm by this ray tracing method that how many times the ray is basically touching the edge if it is touching even number then it is basically it is outside the polygon if it is touching odd number of times the edge it is basically inside the polygon so this is basically the algorithm of ray tracing in point in polygon test there are also development further development of this technology even in in in 2010 also there are some latest version of particular algorithm and they basically improve the efficacy of this particular algorithm.

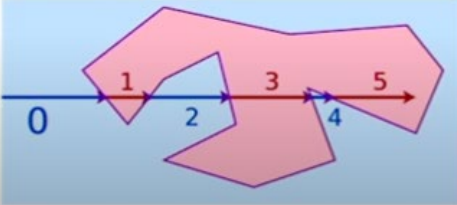
Lecture 19: Introduction to Geo-fencing

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Geofencing Algorithms

The "point-in-polygon test" is a geometric algorithm used to determine whether a given point lies inside or outside a polygon. This test is commonly employed in various applications, including geofencing algorithms and geographic information systems (GIS).

The fundamental idea is to check whether a specific point's coordinates fall within the boundaries of a polygon.



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This can also be used in three-dimensional as well so we will discuss now it three algorithms that is basically used globally on this geofencing system one is the piston that is parallel in memory spatio-temporal topological joint algorithm okay this is basically developed by the University of Toronto computer science department and design is parallel and in memory infrastructure for efficient query in structure extraction execution key features it is novel parallel in memory trajectory index IR for high location data update rates in memory spatial index is with a two-level grid approach optimized for point in polygon test so this method is also been used for the point in polygon test low query response times are suitable for real-time use even with large geofence data set so these algorithm basically develops for different frameworks for different supply chain management issues particularly adhering to the time that there was a some time limit whether the delivery was within the time limit within a within a tolerance limit so for that tracing that particular status of those progress of that process this kind of algorithm is efficiently tracking and monitoring the system SLGC that is can line algorithm and grid compression algorithm it basically originates by the software school of ZMN University of China and its purpose was to address regional limitations in internet of vehicle system with time and storage constraint so it is more optimized in that context operation spherical grid improves on geofence area in pre-processing scan conversion algorithm determines location attributes for each grid cell and quadtree compression provides a memory efficient index structure for geofence area and use motion code MD code to identify nodes inside the quadtree structure then the PFLGA proactive fast and low resource geofencing algorithm this employs a tree-based indexing method for geofences implements a smart trajectory filtering strategy and provides flexibility with both trajectory based and point in polygon queries however it's a response time for trajectory based queries may not be the fastest among available algorithm.

Geo-fencing how keeps the minor shape so geofencing is basically a virtual boundary drawn around a dangerous area on the spatial context of that particular area so this can be achieved with the GPS advancement that is the GNSS and other data signal including the cellular Wi-

Fi and the RFID system the idea that a geofencing application responds instantly when a mobile device enters or leaves the area that is a designated area it can limit personal access to recently blasted areas for example or minimize the time for evacuation due to an explosion by determining the best escape routes a geofencing application can be programmed to set off and alarm on a mobile device if a worker or vehicle operates too close to the edge of a dangerous boundaries so this is a schematic diagram how the geofencing area is designated and defined for example.

The screenshot shows a video player interface. At the top, it says 'Lecture 19: Introduction to Geo-fencing' and 'Geofencing keeps miners safe'. The main content is a schematic diagram of a mining site. A yellow oval represents the mining area, divided into several zones: 'Blasting zone', 'Equipment zone', 'No-go zone', and 'Drilling zone'. Above the oval, a 'Cell tower' is connected to an 'iCloud' cloud, which is then connected to an 'Application Interface' laptop. Below the diagram, the text reads 'schematic diagram of mining with geo-fencing application.' The video player controls at the bottom show a progress bar at 20:16 / 41:53, a volume icon, and a 'YouTube' logo.

So, this is basically the mining yard area okay and this is basically defined by a by a special perimeter it has dimensions so any device any equipment entering to this particular zone it would be alerted and that alert will go to the through the cell tower and network to the iCloud and the application interface that is the mobile device so the inspector or the superintendent of that shift or the manager can see the movement or a status of this particular site through that there also the speed limit zone zone is there so these basically basically estimate whether some vehicle is going beyond the defined speed limit or not so that is also connected through the network and it has a specific boundary there are some no-go zone maybe this is basically temporal sometimes so based on the necessity we define that nobody should go or who are the person they can enter this particular zone that is already defined so any violation of that things can be alerted through the network and to this particular superintendent and to the particular user as well there are some emergency operations as well in the mine site that can also be defined through this geofencing area within the overall legal mining boundary and this is basically the drilling and blasting zone so this is how the geofencing system or algorithm basically works in tandem with other mining operations in the mine.

So, it is basically an extra fail-safe or extra layer of protection that ensure the operation goes on smoothly so the technology can automatically shut down dangerous equipment or alert site manager so that they can take decisive action quickly it's coupled with the telematics geofencing can track the whereabouts of assets and prevent them from leaving a defined area telematics is the technology used to track individual machines or a fleet and the telematics

collects data from vehicles including location driver behavior and vehicle activity it can help management keep track of heavy machinery asset and keep them out of hazardous environment for example if a machine handler is behaving erratically and endangering the safety of others an alert can be sent to the site manager and site manager will take appropriate action.

So, the mining companies nowadays can detect and collect data that indicates truck driver behavior data on harsh driving activity can be seen by the GPS services moreover a mine site manager can easily monitor and detect dangerous driving behavior thanks to the advancement of the GNSS technologies yet once a mine manager detect dangerous driving and operational behavior straight ahead he or she can alert driver on their risky behaviors so this is schematic diagram of a driver doing some erratic behavior that is alerted track minor.

Lecture 19: Introduction to Geo-fencing
Track miners
Detecting Dangerous Driving Behavior

- Mining companies nowadays can detect and collect data that indicates truck driver behavior. Data on harsh driving activity can be seen via GPS devices.
- Moreover, mine site managers can easily monitor and detect dangerous driving behavior thanks to the advanced GPS features.
- Yet, once a mine manager detects dangerous driving and operational behavior, straight ahead he can alert drivers on their risky behaviors.

Driver behaviour detecting

23:40 / 41:53

In addition, this application characterization of the GPS feature can decrease the chances of accident or any injury happening on the mine site because alert is already generated so everybody of that particular vicinity is been alerted so by that an advance notions is been gone through so by that we can decrease the chances of accident in that particular site so by that not only the mining company can decrease the chances of accident or injuries but they can well reduce the wear and tear on the vehicle as well so by detecting dangerous driving behavior via the global positioning system mining companies can improve their overall efficiency.

So, this application characterizes characterization of the GPS feature for mining companies can be seen in the process of hazard avoidance as well so in general the mining industry is a risky one so geofencing will add an extra layer of safety for the miners who working in that particular environment so here we have tried to show you that a virtual boundary is been created loading area A and loading area B different machineries are operating surrounding this area or vicinity of this particular area and all these machines are connected with the network as well as the global positioning system receiver and in these particular mine site at different point there are some network router maybe miss topology or start topology been followed okay and all these devices are connected together so from the server room or a data center nowadays

mining industry is also viewed as a data center because because of the advancement of a huge number of sensing technology in that in this particular data center or a control room a large amount of data is collected so by analyzing all this data we are basically helping a smooth operation of these machines one second we are basically ensuring none of the vehicles collide with each other and third we are basically ensuring that how much amount of rate of production is defined and whether that is progressing in that particular tandem rate or not so in that sense it is basically helps in all the way to achieve higher production and higher productivity in the system and vis-a-vis reducing the chances of accidents.

Lecture 19: Introduction to Geo-fencing

Track miners

Hazard Avoidance

- The application characterization of GPS features for mining companies can be seen in the process of hazard avoidance as well. In general, the mining industry is a risky one. Geofencing will add an extra layer of safety for mine workers.

The diagram illustrates a mining site layout with various zones and infrastructure. Key components include:

- GPS** and **Positioning Information** systems for vehicle tracking.
- Wireless LAN** and **Wireless LAN** for communication.
- Crusher Processing Plant** and **Database Server**.
- Dispatch Room** for monitoring operations.
- Head Road** connecting different areas.
- Loading Area A** and **Loading Area B** for material handling.
- Dumping Area** for waste or byproduct.

Static virtual notification, this application works on geographical position of a mobile user concerning a fixed area and the dynamic virtual notification this application is rooted in the geographical location of a mobile user concerning a changing data stream peer-to-peer virtual notification this application works on the geographical location of a mobile user concerning other users so location accuracy the device location must be correctly identified to a geofence for the for the action to occur appropriately or the right user receives the notification tracking rate is important device speed at what rate device is updating the information that is also important the device route which route it follows in the network the gateway and the locations and the size of the geofence for how big is the geofence area and how many number of constant put in that particular system so these are working together hand-in-hand and by that it enhance the location accuracy.

So, how fleet management is used in geofencing using the Internet of Things planning trips and scheduling trips fleet management uses planning trips and scheduling trips in such a way that owners can plan their trips in a specific manner using the geotracking and communication with the help of the IOT fleet management when a truck driver diverts from his route the dispatcher get an alert so this is used as fleet management using the geofencing maintenance there are hundred number of vehicles operating on a FMS so it is crucial to have conservation of these vehicles and consequences of in appropriate actions blast zone when it is a time to conduct blasting to basically extract the iron ore or coal we need to ensure that no people is

inside that particular blast zone area so a geofence alert system can alert whether right people are in right position or there are some violation in that particular context we can detect by creating a virtual geofence around the blast zone.

Lecture 19: Introduction to Geo-fencing

Geofencing application use in mining industry

Blast Zones

- When it's time to conduct blasting to loosen iron ore for extraction, for example, obviously you need to be sure no people are in the blast zone, so a geofence can alert the right people if and when this occurs.

Geo-fencing

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So, this is an typical image that we are creating a virtual geofence area around the blast zone and we ensure nobody is inside that particular area okay because we also ensure that miners were a kind of sensor that can be detectable so entry exit inside this particular area is very much easily detected yard and site so when we involve a process that transporting some equipment some person transporting some materials to a particular area or a home yard or a yard so to a temporary worksite by creating a geofence it allow you to easily log the time users come and go between each area so you can monitor the advancement or progress of that particular site how the means people those are entrusted to do the work is doing the work for example a concrete truck returning to the yard to fill up and before heading back to the site to drop up its load so all these are locked in this particular system.

Confinement sometimes confinement is also necessary particularly in emergency situations so we can create a virtual boundary in that particular area so that we are not allowing anybody inside or we know very well who are the person is inside that particular area and that log is available and maybe that is used for safety purpose as well confinement is where you want someone to stay within an area or can be set up to send you an alert should they leave the specified zone.

No-go zones functioning similar to blast and emergency geofences this is a solution for area you don't want people to go or to enter although or not necessarily for safety reason maybe some for some other reason as well security sensitive area or environmentally protected zones are good examples emergency for the use of critical situation emergency no zone can be quickly set up for evacuation and warning zones an example of this is a fire zone so when such an event occur and emergency geofence can be created to cover an area to evacuate as soon as the area is mapped out of the system can identify which radio user are in the zone and send

out an alert to ensure they should leave speed limiting heavy industrial areas such as mine site often have certain areas where you are not to exceed a certain speed limit you can define by the geofence technology a speed limit geofence can track any incident of over speeding and help you to send an warning if it is necessary.

In an open pit mines, geofences use for the minor safety if miners enter in the mining area then mining office get a notification if the heavy art moving machinery tracker users can get an alert about the machinery for example production activity and the transportation activity list notification that can also be used we can use within the leasehold boundary notification whether unwanted people are entering to that particular area we can also monitor human resource management and employee using the smart card of the GPS tracking device will send an alert to security if an employee attempt to enter an unauthorized area within the geofence area.

Compliance management network logs records all geofences crossing to document when the proper use of the device was happen and whether we are basically following the rules and regulation that is compliance monitoring can also be done using this geofencing technology asset management an RFID tag on a pellet can send an alert or notification if the pellet is removed from the warehouse without any authorized without any authorization law enforcement can also be enforced using this kind of system.

Question number one how does the geofencing technology impact the mining industry? (A) it has no impact on the mining industry (B) it creates physical perimeter and on the designated area (C) it relies solely on the GPS for real-time monitoring (D) it revolutionizes the industry by enabling virtual perimeter and automated responses (E) it only monitors asset not people within the virtual fences.


The right answer is (D) it revolutionizes the industry by enabling virtual perimeters and automated responses.

So, these are the key features geofencing and access control access control is a very important feature and that ensured that no unauthorized action is there only the authorized person get entry into the network and also it ensure that a fair amount of information is here within the network real-time tracking and visualization these basically helps from the prevent of view of the control station so from the control station or the supervisor can see visually the real status in real time and through the visualization mode through the Android device or the industrial gadgets or the computers intelligent routing and dispatch management can also be used efficiently using these geofencing technology automated alert and notification can also be used using this geofencing system in the mining driver and fleet management system can also be done using this system performance analytics and reporting because you are generating data on a real-time basis and all the data structured on a database so it is very easy to generate the reports and their compliance with the with the regulatory systems emergency response integration can also be done and to be integrated within the system.

geofencing access control implementation of geofencing technology to create virtual boundaries around excavation zones only authorized vehicles and equipment can enter specific areas preventing accidental encroachment and ensuring a safer work environment so this is a particular example that geofences is created around the area and we are ensuring that right vehicle or right place and those are unauthorized vehicles not get entry into this particular area.

Lecture 19: Introduction to Geo-fencing
Real-Time Tracking and Visualization:

- The system integrates GPS and RFID technologies to track the location and movement of all excavators and vehicles in real time. A user-friendly interface displays the mining site layout with color-coded zones, enabling operators to monitor activities and detect any unauthorized entry.



Real-Time Tracking of fleet movements and notification of event on Geo-Fenced Area access

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Real-time tracking and visualization the system integrates GNSS and RFID technology to track the location and movement of all excavator and vehicles in real time user-friendly interface display the mining site layout with color-coded zones and enabling operator to monitor the activities and detect any unauthorized entry so there are some color-coded contour zones that basically detects in real time whether the particular fleet is in that particular area.

Intelligent routing and dispatch management the system employ predictive analytics and AI algorithm to recommend optimal route for each vehicle and excavator so these minimize traffic congestion reduce turnaround times and enhance overall operational efficiency and dispatch manager receive real-time suggestion to make informed decision or more scientific decision or more objective decision based on the data additionally manual route planning can be implemented with geofencing to assist drivers in adding to the designated route in any division from the plan route within the geofence area can be tracked in real time so whenever an event of geofence breach occur a real-time alert can be generated and reported to the appropriate persons and the manager.

Automated alert and notification, when a vehicle or excavator enters a restricted or active excavation zone the system triggers automated alert to relevant stakeholders including operator supervisor and the driver so these alert prompt immediate corrective action and prevent safety hazard and resource wastage.

Driver fleet mapping, enabling an access control system that links driver to specific vehicles facilitate the process of assigning vehicles and aligning driver with the designated shift only so this system ensure that access is granted exclusively to vehicles that have the pre-approved and onboard on boarded by the fleet manager so moreover this access control mechanism serves the vital purpose of restricting unauthorized personnel from entering vehicle located in hazardous areas only individuals who have undergone specialized training are permitted to access and operate these specific vehicles. it's most important to note that the vehicle operation

is only allowed once a trip has been officially assigned otherwise alert can be generated for such event to enable quick preventive action.

Performance analytics and reporting, so the system collect data on vehicle movement operational pattern and efficiency matrix so by all these data we have a further scope for improvement of this process so detailed reports are generated such as fleet utilization reports delay miss report entry plan incident report total kilometer covered report driver wise report and customized report based on operational requirement providing insight into performance trends and potential bottleneck areas for improvements emergency response integration the system includes an emergency override feature that allow operator to remotely halt vehicle and equipment in case of a safety threat so this ensure swift action to prevent accident or hazardous situations.

These are the references.

So, let me conclude in a few sentences what we have covered in this lesson. We have provided an overview of the concept of geofencing, and we have explored the practical application and integration of geofencing technology. We have discussed different algorithms that is been used in the geofencing technology for defining the virtual boundary and their entry system. We have explored the role of geofencing in enhancing the safety measures for miners. We have discussed how geofencing is utilised to track and monitor the movements of the miner we have examined the practical application of the geofencing technology we have explored a specific use cases for geofencing technology within the mining sector we have highlighted essential feature that make geofencing valuable for enhancing safety and monitoring in mining operations.

Thank you