Industrial Safety Engineering
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Lecture – 57
**Virtual Reality-Introduction**

Hello everybody, so, good day today we are going to start the new topic Virtual Reality. In fact, the lectures will be taken by my scholar (Refer Time: 00:33); in fact, he is doing PhD work in this area virtual reality application to safety management and being a new topic and very relevant topic in the context of industry 4.0. And in the context of safety engineering particularly from hazard recognition, avoidance and prevention through design point of view.

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We have been working in this area for couple of years and recently we have developed our laboratory and that is safety analytics and virtual reality laboratory. The lab is equipped with requisite hardware and software related to virtual reality based modelling, simulation, data visualization hands on training and related activities.

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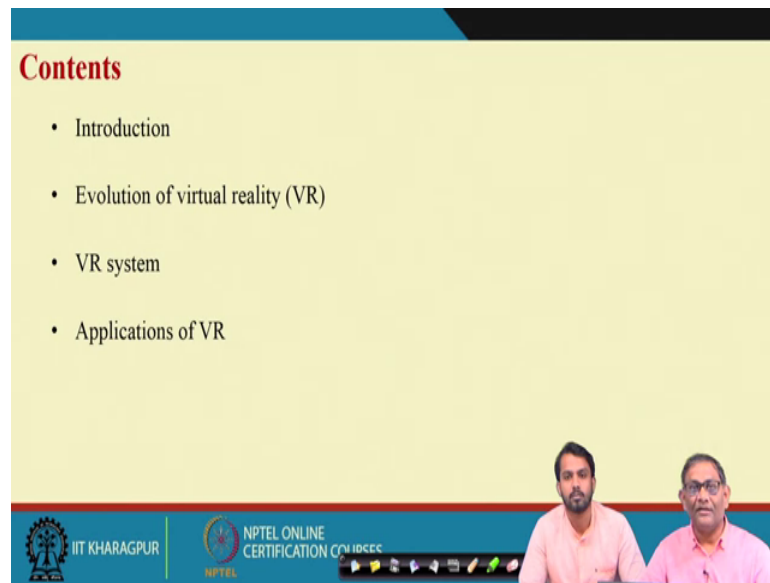
So, in this first lecture the content will be first the what is virtual reality and different aspects of virtual reality? Then evolution of virtual reality over time and then what do you mean by virtual reality system as a whole and then applications of virtual reality not necessarily in the area of safety industrial safety in the area of other applications other industrial applications.

So, with this few words I am just handing over this lecture material to my research scholar my beloved student Mister (Refer Time: 02:30). He will take you through the virtual reality lectures 3 or 4 lectures including the today's one and I am sure that you will enjoy the lectures and this is the some kind of additional or advanced topics related to industrial safety engineering. So, you try to garb as much as possible from this lecture and Kranti you please continue.

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Hello everyone, so, as Professor Maiti introduced I will take you to the through the lectures of this particular video. So, first is let us go to the introduction what is virtual reality? So, virtual reality can be defined as inducing targeted behaviour in an organism by using artificial sensory simulation; while the organism has little or no awareness of the interference. So, in this particular definition the 3 important terms are targeted creation of targeted behaviour in an organism using artificial sensory simulation and the users should not be having any awareness of the interference that is created.

That means it is not the normal is normal simulation that sensory simulation, it is the artificially created sensory simulation in an organism to achieve a certain objective that is create a certain targeted behaviour. So, what are the key elements in a virtual reality? Virtual reality environment so, first one is the virtual world, second is immersion, third is sensory feedback and fourth is the interactivity. So, let us see what is virtual world an imaginary space obtained through a medium which is the collection of objects in a space and certain rules associated with that those particular objects.

Similarly, so immersion means sensation of a user being in the virtual world; means sensation of a sensation like to the user being present in that particular virtual world, it can be mental state or can be obtained through any physical means. Then sensory feedback it is the visual sense that receives feedback based on users position and this feedback requires high speed computer as a medium. The computer having high end

graphics card and high speed RAM, which will help in obtaining different sensory feedbacks.

And final is the interactivity it is the users ability to interact with the virtual world by changing position picking up objects and settling them down. For the interactivity purpose we are certain hand tracking; hand tracking devices and certain sensors are used so, that the interaction will be possible of users interaction will be possible with respect to the created virtual world.

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So, let us see how the virtual reality techniques or the virtual reality complete virtual reality is evaluated. So, first it started with invention of flight simulator which is which is the work of Edwin Link in 1929. Then Morton Heilig, he invented the multimodal display system which is otherwise called as Sensorama.

Similarly, next is the invention of head mounted display by Comeau and Bryan in 1961; then the famous researcher Ivan Sutherland, who invented the interactivity interactive computer graphics with sketchpad application and finally, he went to invent ultimate display interaction of user with object avoiding loss of physical reality in 1965 also.

Then he went on to invent the image generation system novoview for flight simulation. Then artificial reality environment by Myron Krueger in 1976 and the Sayre Glove is the interact interaction device that is invented in the year of 1977 in electronic and

visualization lab of University of Illinois. Then Eric Howlett he actually developed this large expanse enhanced system perspective system in which wide field of view from a small display can be generated.

Then Brooks Junior he invented the VR system adding HMDs, optical trackers and graphics engines. And finally, the CAVE system is which is a virtual reality visualization system, it is developed in a in the same electronic virtual visualization lab of University of Illinois.

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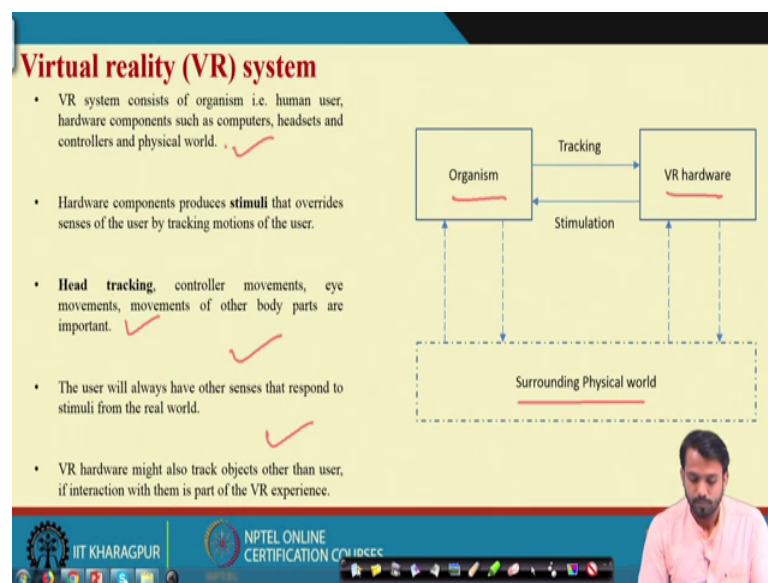
So, what is the virtual reality system is composed of? So, first one is virtual look at this diagram so, there are main 3 main phases of this diagram. First is organism first is the organism then is the VR hardware then is surrounding physical world organism, VR hardware and surrounding and physical world. So, the organisms any movement or activity is tracked with the help of VR hardware and the simulation will be propagated to the organism also by creating artificial sensory simulation which I already explained the first slide.

So, the VR system consists of organism that is human user, hardware components such as computers and headsets and controllers and physical world. So, the hardware components produce stimuli that overrides the senses of the user by tracking motions of the user; that means, the over override the senses of the user means the user must not be having any interference of the artificial sensory simulation created.

Then head tracking, controller movements and eye movements and along with that movements of other body parts are very important which is tracked by the use of virtual reality system. Then user will always have other sensors that will respond to the stimuli from the world real world. Then VR hardware might also track objects other than user if interaction with the object is created inside this particular virtual reality develop virtual reality environment.

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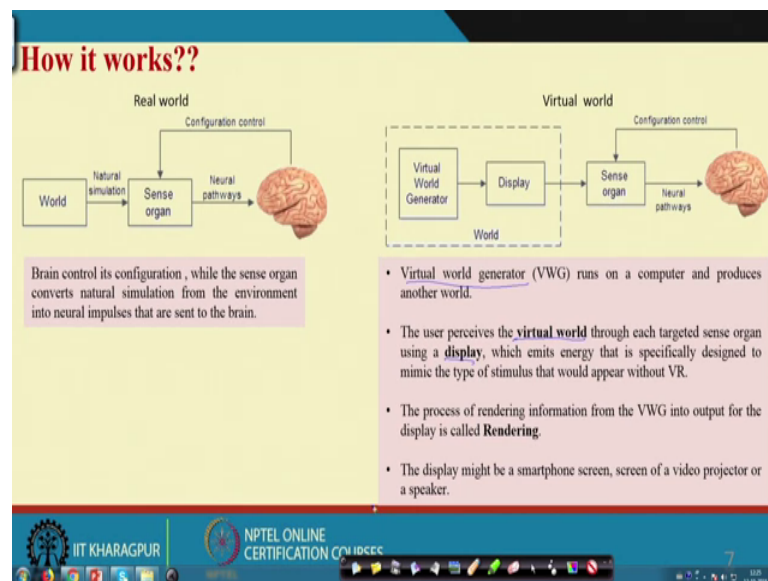
So, how it works? So, this is a comparison between the real world and this virtual world. So, in this real world the natural simulation will be propagated to the sense organs of user; that means human and it will go to directly go to the brain and brain will accordingly act as per the received simulation. That means, brain control it is configuration while the sense organ converts the natural simulation from the environment into neural impulses that are sent to the human brain.

So, in the virtual environment what is the case? The virtual world generator runs on a computer and produces another world that is different from the real world. So, the user will perceive the virtual world through each targeted sense organ using a display and which emits energy that is specifically designed to mimic the time type of stimulus that would appear without VR. That means, in this case the most important part is the virtual world generator, then the user perceives the virtual world with the help of display.

The process of rendering the information from the virtual world generator into output for the display is called as the rendering. Rendering process is converting the information from a virtual world to the necessary output desired output is called as the rendering. The display might be a smartphone screen, screen of a video projector or speaker; now a days you can see most of the androids or iphone mobiles is having virtual reality; virtual reality technique. So, that it is very easy for the people for the user to use this technique for any certain creation of virtual environment and certain user interaction.

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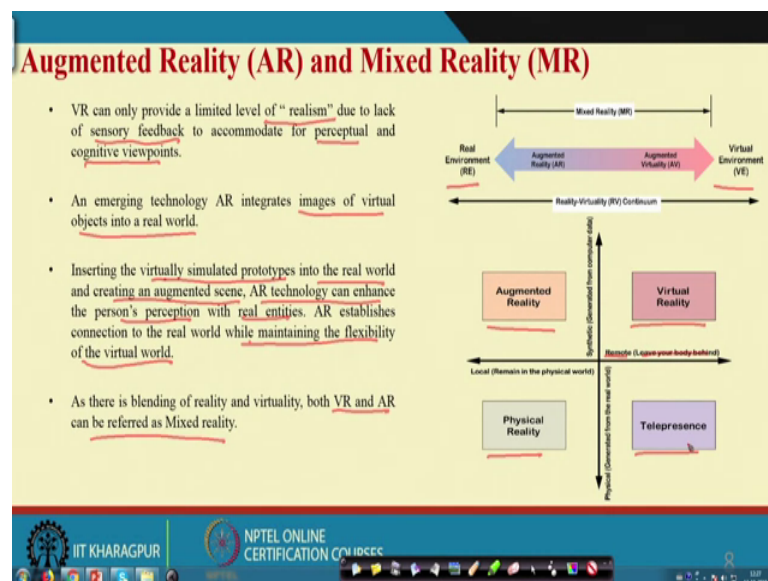
So, now let us see what is augmented reality and what is mixed reality? So, VR can only give feedback which is limit in level of realism means VR involve limited level of realism due to lack of certain sensory feedback and which is not that is; because of this reason so perceptual and cognitive viewpoints are not accommodated in the virtual reality system. So, this is now overcome by the application of augmented reality which is an emerging technique and which integrates the images of virtual object into a real world.

That means inserting the actually simulated prototypes into the real world and creating an augmented scene. AR technology can enhance the persons perception with real entities; persons perception with real entities that means, virtual reality lacks the perceptual and cognitive viewpoints which is overcome by the overcome by the augmented reality. And AR establishes the connection to the real world while

maintaining the flexibility of the virtual world it should not be it should not happen that virtual world will lose it is flexibility because of this application of augmented reality.

So, as there is blending of this reality and virtuality both VR and AR can be referred as the mixed reality, which is the most commonly used term now a days the mixed reality. So, see here this real environment, virtual environment and augmented reality which creates the bridge between the both real and virtual environment. So, virtual reality is remotely the user will be using it remotely living your body behind. Then physical reality in which the user will be interacting with the physical objects in the real world.

And the augmented reality which I already explained in which perceptual and the cognitive sense can be created. And the telepresence, telepresence means the remotely you can operate any certain operation the any certain desired operation. That means, now a days in healthcare system certain surgical operations; surgical procedures are performed remotely by the healthcare experts. So, these are called as a telepresence remotely using the virtual reality.

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So, what are the VR hardware components let us see; first is the displays. So, displays are the physical perception of the virtual world is based on entirely on what the computer displays. So, display is a method of presenting information to any of the senses; it maybe visual, it may be aural or it may be haptic. So, there are 3 kinds of display system first is a stationary display then head based display and hand based display.

So, stationary display are fixed in a place and the output is rendered to reflect the changing position of users input sensory organ. So, it is basically monitor based or projection based using different 3D projection systems. Then head based displays which is which are worn or attached to the users head or move along with the head, here the display move and remain in a fixed position relative to body's sensory inputs.

So, example of these are occlusive HMDs Head Mounted Display and nonocclusive head mounted displays. And finally, the hard hand based displays which move in conjunction with users hand and all senses cannot receive stimuli from all types of displays. So, these are the hand based display are least used now a days. So, mostly you hand head based display and stationary display are used for the purpose of create for the purpose of displaying the sensory simulation to the user.

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So, let us see what are the visual depth cues? So, human whiles while visualizing perceiving perceive information regarding the relative distance of the objects; relative distance of the objects in various ways and these indicators of distance are called as the depth cues.

Means, while visualization what the user is perceiving among the distance of object that is called as your visual depth cues. So, 3 three types of visual depth cues depth cues are there; first is monoscopic image depth cues, second is stereoscopic, then motion depth cues and final is the physiological depth cues. So, monoscopic depth cues is related to

the static view of a scene as in photographs and paintings, you can see this monoscopic depth cues. Similarly, stereoscopic this depth cues is which depends on parallax which is the apparent displacement of the object viewed from different location.

And motion depth cues are that it depends on the parallax created by the changing of relative position of the head and the objects being observed. And final one is the physiological depth cues which are generated by the eyes muscle to bring an object to into a clear view. So, apart from visual depth cues let us see what are the vision, sound and touch that are very important for the VR hardware.

So, for the vision purpose now a days DLP that is Digital Light Processing projectors are used or LCD, Liquid Crystal Display projector are used or LCoS that is Liquid Crystal on Silicon are the latest display techniques which are already customized for VR; some of the examples are Google Glass, Microsoft Hololens and Avegant Glyph.

So, for the sound purpose speaker technology are used latest technology includes bone conduction method this is very important; which is now a days a major breakthrough in the in the domain of research, virtuality research that is the bone conduction method which vibrate the skull and propagate the waves into the inner ear that is the use of Google Glass are the Google Glasses are very much used for this purpose. And the purpose of touch haptic displays are use 6 degree of freedom or 8 degree of freedom haptic devices are used in which feedback can be given in the form of vibration, pressure or temperature.

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Next the interface to the virtual world; so, VR system needs hardware devices that monitor the user in order to provide the user information necessary to make a display physically immersive. And inputs from the user are also enable to or enable them to interact with the virtual world. So, there are 2 types of input to a VR application that is user monitoring and world monitoring.

So, user monitoring includes continuous tracking of both users movement and users initiated actions. So, active there are 2 kinds of user monitoring also so, first one is the active user monitoring and second one is the passive user monitoring. In the active user monitoring user inputs the information into the system; that means, the examples can be given as use of spoken commands, physical control like wands, joysticks, steering wheels and keyboards these are the active user monitoring devices.

Similarly, the there are some passive user monitoring devices also. So, in which in passive user monitoring information is supplied to the computer about where and how user is moving and how they are looking inside this particular virtual created virtual environment. So, this passive user monitoring can be achieved with the help of body tracking; that means, hands, eyes and feet movement can be tracked; along with position tracking; that means, user location and orientation whenever there is a motion of user with respect to virtual environment. So, users location and orientation can be tracked

with the help of position tracking that will come under the umbrella of this passive user monitoring.

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Now, after the user monitoring the world monitoring; the world monitoring is here the real world input and information about change in virtual world is carried through time or user manipulation. The real world input is often used to create portions of virtual world in real time; this type of information is gathered by transducers application of transducers which is a equipment that gathers information and translates the data and which report information about a portion of the real world.

That means, the example is weather monitoring station the what they do? They use the transducer to gather the information about this real world and translates the data and converts into a propagates that information to a virtual world. So, this is the use of the weather monitoring station. Now, the inclusion of real world data in a VR application is very helpful in various scenarios; such as analyzing and exploring acquired scientific data, then preventing users from colliding with objects in the real world.

Then preparing a real world for a dangerous task which cannot be which is very much easier to train in the virtual environment. Then planning for modifying or using real world space and finally, the educational experiences in which the training educational training is given to pedestrians some of the examples are training to the pedestrian,

training to the firefighters. So, this kinds of educational experience also can be given to the users.

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Finally, the computers which executes the virtual which executes the virtual world generation the location of PCs are very much important for body fixed displays. If separate PC is needed to power the system fast reliable and fast reliable communication must be provided between the headset and PC; that means, the connection between the headset, head mounted display and the computer should be that much fast and reliable.

Specialized computing hardware like graphical processing unit; GPUs have been optimized for quickly rendering graphics to a screen and they are adapted to handle specific performance demand of any virtual reality applications. Then display interface chips are also used to convert input videos to display commands. Then microcontrollers are also frequently used to gather the information from sensing devices which are used for the artificial sensory simulation and send them to main computer using standard protocol such as USB.

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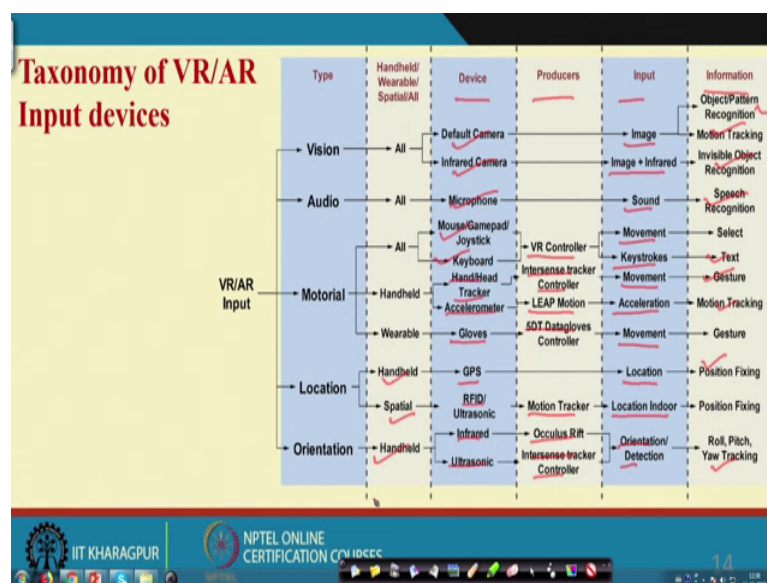
So, these are the some taxonomy of virtual reality and AR augmented reality input devices. So, here the type handheld wearable and spatial devices are also there spatial techniques are also there. Then what are the devices used for that, then who are the producers input and information what are the information we are obtaining. So, for the vision, audio, motorial, location and orientation different VR and VR AR input is written here.

So, for vision all kinds of hand all kinds of; all kinds are possible that is handheld possible wearable will possible and spatial also possible; likewise for the location handheld spatial and orientation handheld are possible. So, for what are the devices those are used for the for this purpose? So, first is the default camera infrared camera then microphone for the audio purpose.

Then for the motorial purpose what you are using? Mouse, gamepad, joystick, keyboards; for the handheld devices hand and head trackers are used. Then accelerometer which is generally used for the tracking of users head movement; then the wearable devices gloves, data gloves or different kinds of (Refer Time: 22:04) gloves are used in which the users finger motion are captured and different activities regarding this wrist motion and the your pitch roll can be captured with the help of this gloves.

So, for the location purpose now a days GPS and RFID techniques are used along with this ultrasonic techniques and the for the orientation infrared and ultrasonic devices are

used. So, the producers regarding this are VR controllers intersense tracker controllers these are some reputed devices controller producer devices; LEAP motion 5DT datagloves, then motion tracker, occulus Rift, intersense tracker controllers are also used.

So, for this devices the inputs are for the vision the inputs are image or image plus infrared. For the audio obviously, the input is sound for the motorial inputs are movement keystrokes and for the handheld, you can say movement and acceleration and for the wearable the input will be movement. And similarly for the location we are getting the input as a location, then location indoor or outdoor orientation and detection.

So, what are the different information we are getting? The pattern recognition, motion tracking is also possible invisible object can be recognized then speech recognition then select text and gesture also can be obtained, then motion tracking position fixing, roll pitch, yaw tracking. So, these are the information we can obtain with the help of this VR and AR input devices.

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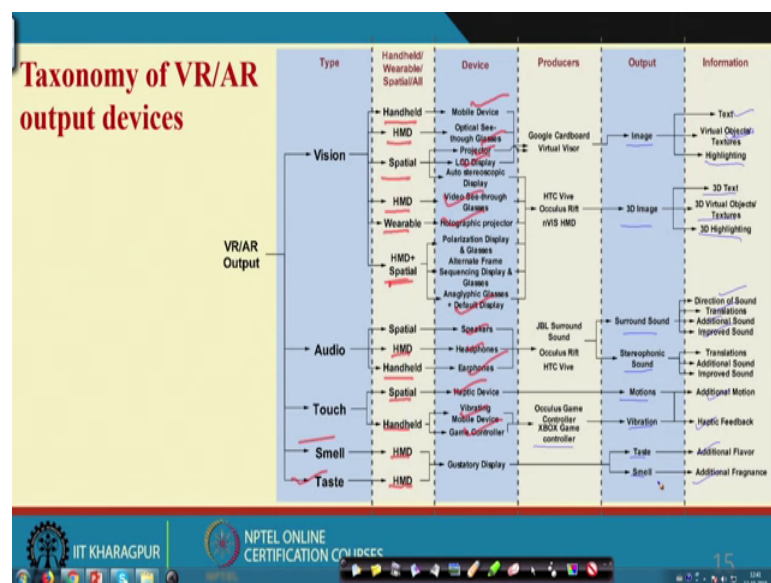
So, similarly for what are the VR AR output devices and what are their output and information we are obtaining, it is clearly mentioned here. So, for the for similarly for the vision, audio, touch, smell and taste this kinds of output what are the outputs we are obtaining from this we will see here. So, basically for the vision purpose the device that are used is handheld devices or head mounted devices or spatial devices HMD wearable and both HMD plus spatial. For the audio purpose HMD are also used handheld devices

are also used, for the touch purpose handheld device and spatial devices are also used and smell HMD and for the taste HMD are used.

So, what are the devices; relevant devices used for the for this purpose so, mobile devices, optical devices, projectors, LCD displays, then video see through glasses, holographic projector, then polarization display and glasses anaglyphic glasses and default devices are also used. For the purpose of audio also obviously, speakers, headphones and earphones are used. For the touch purpose haptic devices, vibrating mobile devices and game controllers are also used.

Then for the smell and taste purpose gustatory display are used. So, who are the producer for this particular devices? Google cardboard and the virtual Google cardboard and the virtual devices Occulus and Occulus Rift and Nvis HMD are used. Then the JBL sound so, surrounding sound Occulus Rift, HTC Vive, Occulus game XBOX controller are also used.

Then what are the output we are obtaining from this kind of devices let us see; the image then 3D images surrounding sound stereoscopic and sound and different kinds of motion and vibration along with taste and smell for the type of output device like smell and taste. And the finally, let see what are the information we are obtaining with the help of this kind of devices which are which you are using.

First is text kind of information we can obtain then virtual information about this virtual objects highlighting, 3D text and 3D textures can also be obtained along with 3D highlighting. Then what are the direction in which sound is propagating translations, additional sound and improve sound also we can obtain with the help of this devices. Then motion along with haptic feedback we can obtain then flavour and fragrance of the different users in the virtual environment can be obtained with the help of this VR AR output devices.

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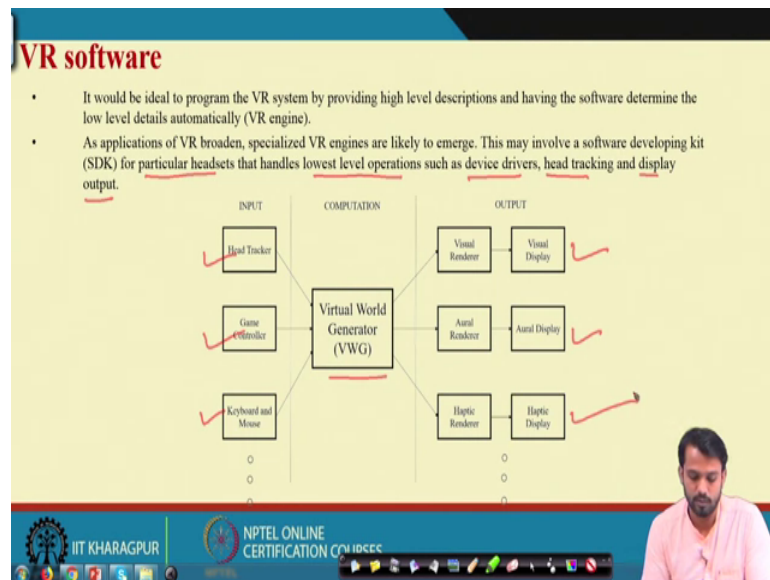
So, these are some softwares so, VR softwares it would be ideal to program the VR system by providing high level description and having the software that determines the low level details automatically; that means, in a VR engine low level detail detailing of the environment can be done automatically.

So, in application of VR broaden special is VR engines are likely to emerge. So, this may involve a software developing kit that is called as SDK for particular headsets whichever headset you are using for that particular headset we can develop the software development kit. That handles the lowest level of operation such as device drivers, head tracking and a display outputs.

Nowadays HMDs are enabled with the SDKs, which we you can directly used for the purpose of this head tracking and the display outputs. So, these are certain input devices that are used for the softer part head trackers, game controllers and the keyboard and mouse. So, it will be fed to the information will be fed to the virtual world generator and output will be in the term of visual display aural display and haptic displays.

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So, let see in the this virtual VR software part what is the difference between this real world and the synthetic world? So, virtual world could be completely synthetic where numerous triangles can be defined in a 3D space along with the material that indicate how they interact with loud light sound and forces and computer graphics addresses the images from this particular synthetic models. Then virtual world might be recorded physical world as a physical world that was captured using modern cameras computer vision and simultaneous localization and mapping techniques that are the slam techniques.

Then matched motion; so, most basic operation of the virtual world generator used to maintain a correspondence between users motion in the real world and the virtual world. In this in the real world the user's motion are combined with safer region which is called as the matched zone. So, user can perform means necessary operation in a safer zone that is called as your matched zone.

And one of the greatest challenge the virtual environment is mismatching within the obstacles. Finally, the user locomotion in many very VR many VR experiences you just want to move well outside of the matched zone this motivates locomotion which means the movement in virtual world, but this motion is not match with the real world.

So, outside the safer zone the user can move also which is called as your locomotion. So, this is the in this particular thing the users motion will be not match with the real world.

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So, certain physics networked experiences and developer choices for the virtual world generator we will explain we will discuss also. So, the VWG that is Virtual World Generator handles the geometric aspect of the motion by applying appropriate mathematical transformation we will which will we will see in the next lectures.

Though VWG usually implement some physics; so that that as a time progress, the virtual world behaves like the real world that the user should feel that he is emerged in that virtual world though emerged in the virtual world which is the replica of the particular real world. So, one important aspect is application of collision detection algorithm which determines whether the 2 or more bodies are intersecting in the virtual world.

So, there should be collision between the user and the particular object present in the virtual world otherwise there will be propagation through the particular object that is present in the virtual environment. Then network experiments experiences in the case of networked VR experience a shared virtual world is maintained by a server, in which user has a distinct match zone there match zones might overlap in the real world, but one must be careful about this matching; so, that they avoid unwanted collisions.

And developer choice is for the virtual world generators also means maintain. So, developer may use a readymade virtual world generator which is customized to make a particular VR experiences. For that purpose open simulator wizard 5.0 now, it is wizard

6.0, then unity 3D; unity 3D and unreal engine and also used for this purpose. So, developer can start from start creating a SDK from for a headset with his own virtual world generator or use the existing virtual world generated devices virtual world generator devices along with inbuilt SDK that is software development kits.

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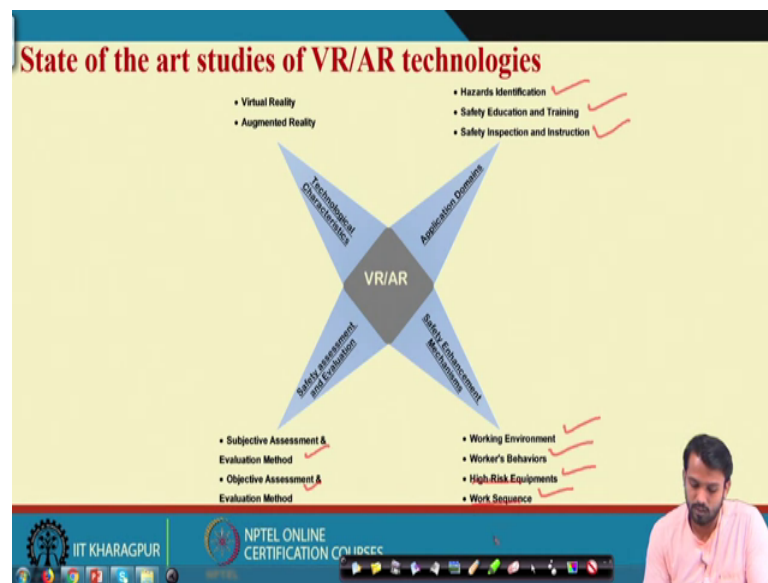
So, what are the state of art of studies using this VR and AR technique techniques? So, the technological characteristics are both your virtual reality and augmented reality. So, an application domains are basically focus in hazard identification, safety education and training, safety inspection and instruction so, these are all the application related to the safety domain; though VR and AR apply to many domains like safe mining training, healthcare training and fire fighting training.

So, we are focusing on the safety domain in which hazard identification, safety education and training, then safety inspection and instruction can also be done. So, what are the safety enhancement mechanism that can be in cure; where the safety enhancement mechanism can be incorporated? First is your working environment, then for the workers behavior then regarding the high risk equipments simulation, then work sequence work plan and work sequence.

So, finally, you are created environment or virtual generator virtual world can be evaluated also with the respect of safety. So, for that subjective assessment and

evaluation method is used and objective assessment and evaluation method are used now a days. So, let us see what certain applications regarding this virtual reality.

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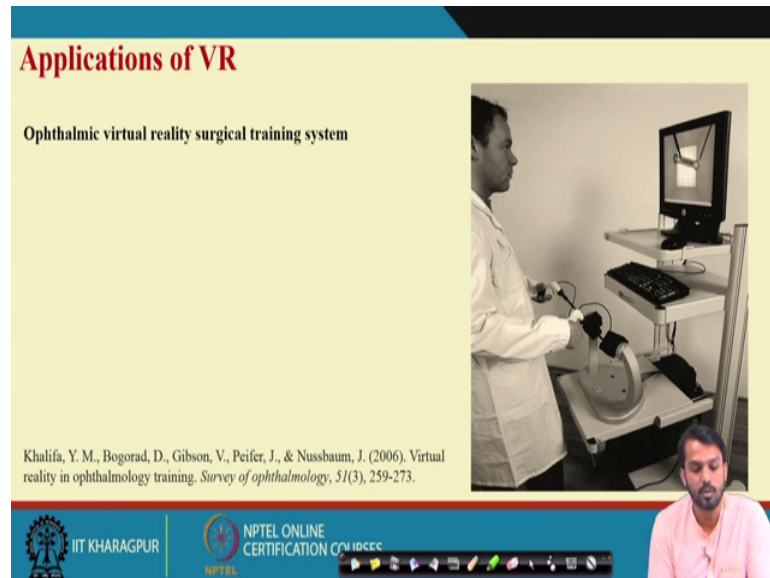
Here you can see applications of VR; so this is this is from the general of virtual reality in ophthalmology training which is published in survey of ophthalmology and this is ophthalmology ophthalmic virtual reality surgical training system; we can see how they are using the virtual reality technique for the surgery purpose, surgical training system purpose.

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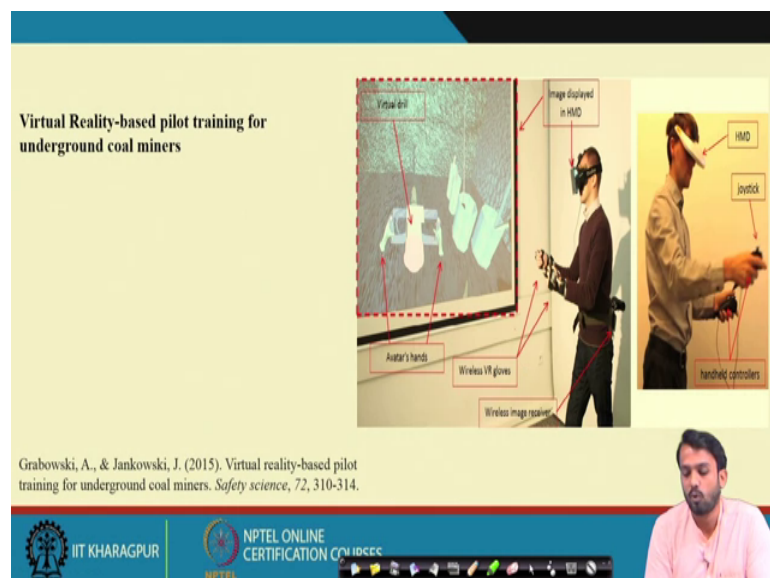
Similarly, you can see virtual reality based pilot training for underground coal miners; it is published in the safety science journal virtual reality based pilot training for underground coal miners in the year of 2015. So, here the operators are mined coal miners were trained in the virtual environment; regarding the how to operate inside an old underground coal mining.
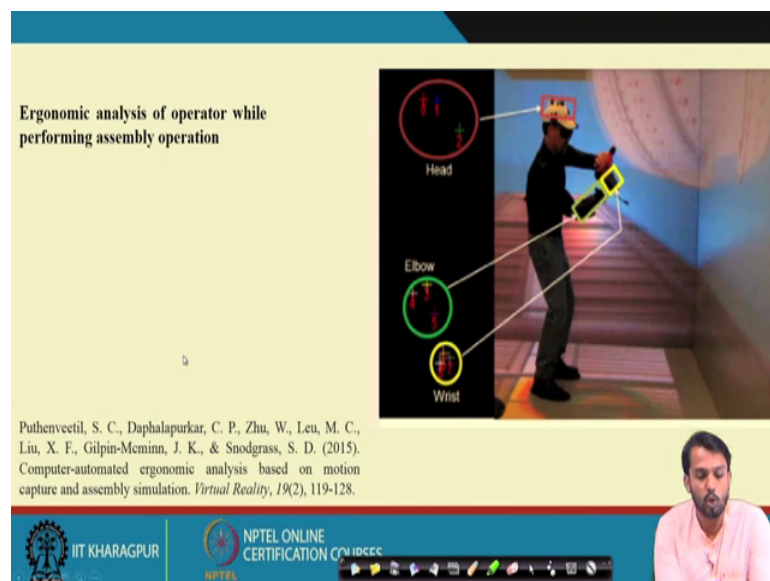
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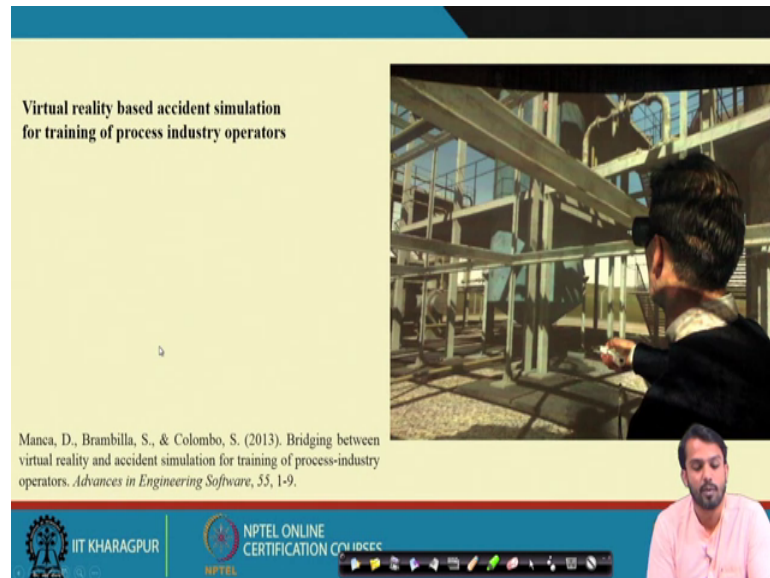
Now, here you can see virtual reality based accident simulation for training of a processing industry operators it is published in the Advanced Engineering Software journal in 2013 in which the operators are trained in the process industry for the standard operating to learn the standard operating procedure, how they will interact with different devices present in the process industries.
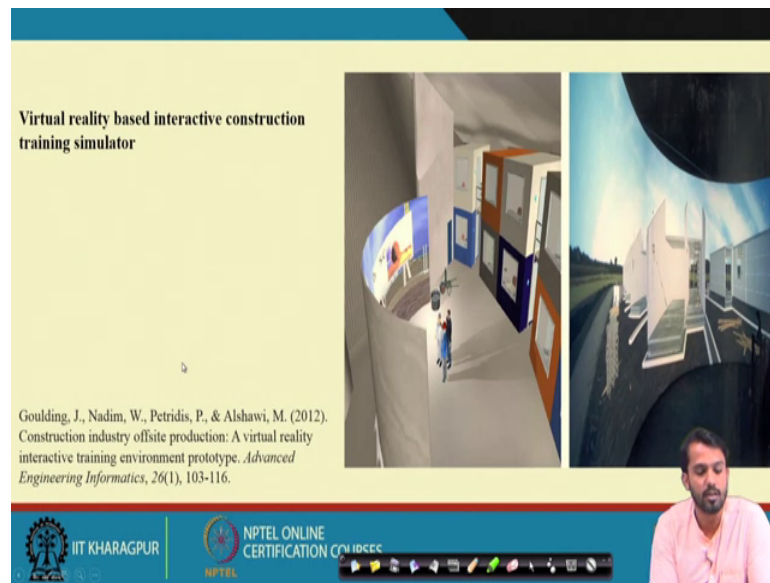
Similarly, the virtual reality based interactive construction training simulator; here the newly joined construction worker will be trained, how to interact with the different kinds of devices or different kinds of equipments that are present in the construction off site or on site. So, this is published in the journal of Advanced Engineering Informatics in 2012. So in the construction site how you will train your operators or construction workers to react to different kinds of hazardous situation; along with to different standard operating procedures.

Now, ergonomic analysis of the operator also can be performed while assembly operation with the help of this virtual reality techniques.

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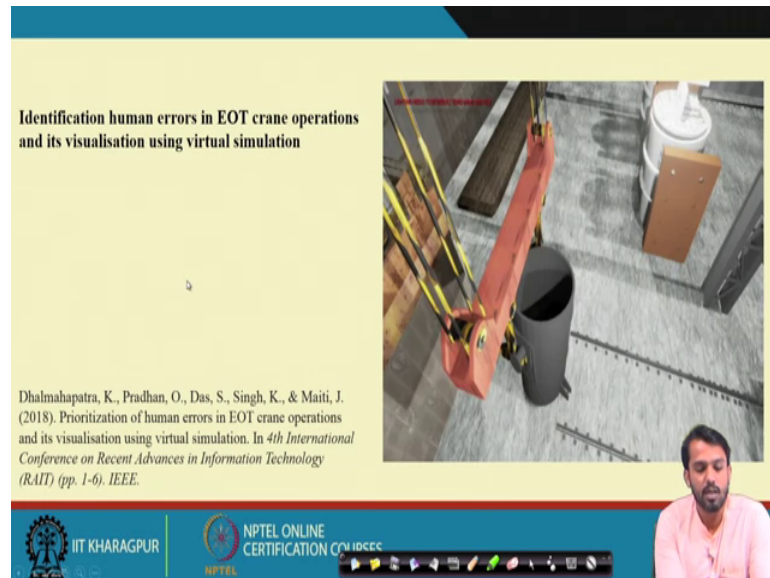
Now, identification of human error in EOT crane operation and visualization of using virtual simulation it is publishing in the this work is published in the Conference of Recent Advances in Information Technology in 2018 K. Dhalmahapatra and J. Maiti.

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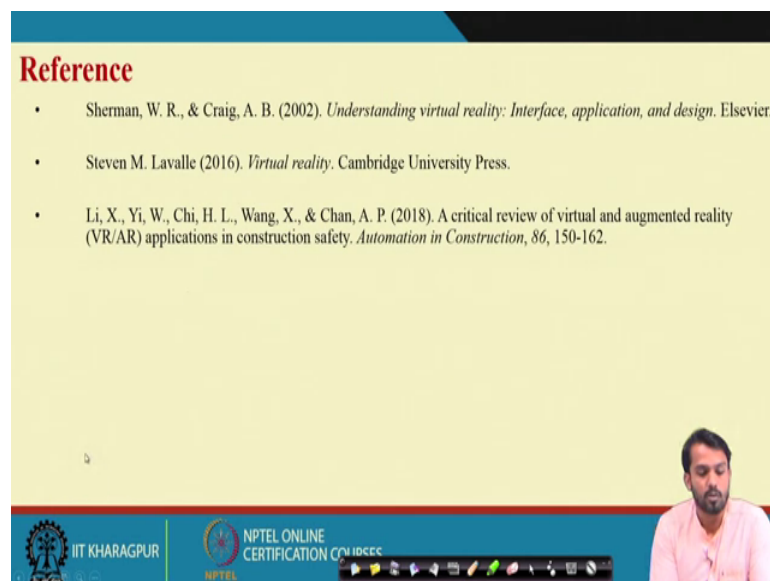
So, these are some references input and references regarding this particular lecture. So, where we adopt this techniques and connecting information regarding this lectures. So,

understanding virtual reality a book by Sherman and Craig; Sherman and Craig, then Steven M. Lavalle virtual reality book, then this is the particular journal a critical review of virtual reality and augmented reality applications in construction safety. So, in this particular lectures so, what let we saw how to approach to virtual reality?

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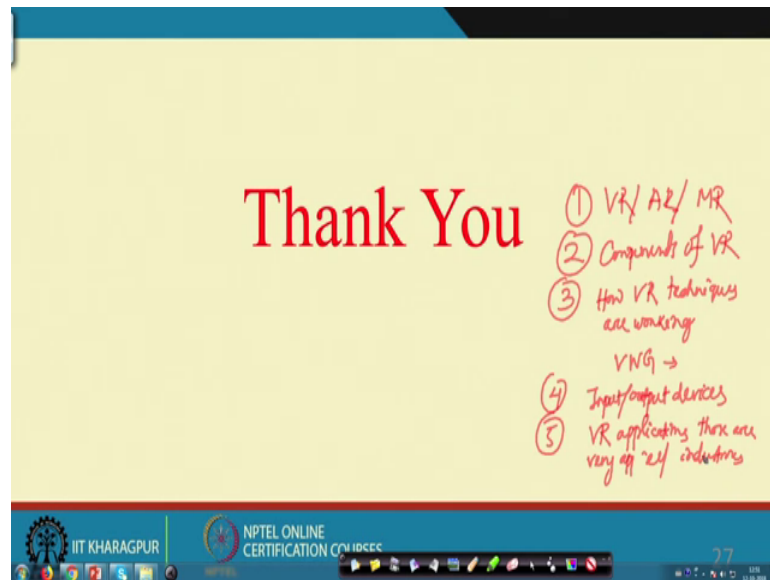
So, what is virtual reality VR what is AR and what is MR and how the what is the components of the virtual reality system; that means, component of virtual reality. Then how the VR techniques are working; that means how the virtual world is generated that is VWG; Virtual World Generator. Then what are the input and output devices that are now a days used for the creation of virtual reality and augmented reality. And finally, what are the applications VR applications recent VR application those are very much applied to different very much applied to different industries.

So, I hope this lecture will help you to gain certain knowledge about the virtual reality techniques although you can refer these books and the references which I have provided for the better knowledge of this virtual regarding is virtual reality augmented reality and the mixed reality. And you can also think of how to apply this virtual reality technique for training purpose or hazard identification purpose or hazard recognition purpose in your particular work place in which you are working.

Thank you.