**Introduction to Industry 4.0 and Industrial Internet of Things**
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**Lecture – 13**
**Industry 4.0: Augmented Reality and Virtual Reality**

In this lecture we are going to get a brief overview of Augmented Reality and Virtual Reality in the context of a IIoT. So, augmented reality and virtual reality, they are popularly known as AR and VR, are quite important technologies, that have been adopted and are being adopted at present in different IIoT context, in the different industries. Because of different advantages that they offer, there they have some relationship between them they are interlinked, but they have some distinct differences.

So, in the next few minutes, we are going to understand the specific attributes of AR and VR and the different challenges, that are there in the adoption of AR and VR technologies in IIoT settings.

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So, from a technological perspective, both AR and VR they can be used in different context, different industry sectors, they can be used and together they can help in improving Industry 4.0. So, they play a very important role in the primary stages of manufacturing, where optimization and productivity are important considerations. Because in any manufacturing industry it is not just the manufacturing of the product,

optimization of the processes, improvement of the productivity, these are important considerations. The efficiency of warehouses is also very important and these can be improved using different AR applications. Both AR and VR are also important in safety scenarios.

So, for example, there are situations I will also talk about a scenario, where VR as well as AR can be used for training of industrial safety. So, we will talk about that in another lecture not in this lecture. So, I will showcase how AR VR can be used to improve the training of safety in industrial plants. So, these are very important technologies. So, that is the reason why I thought that a basic understanding about these technologies can help in improving the IIoT infrastructure in the industries.

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The different use cases that are served by AR and VR for IIoT are things like machining and production. These technologies AR VR can be used to improve the overall machining processes, production processes, and in education, training, collaboration, assembly line, safety security of different infrastructure in the industries. And digital prototyping, factory planning, maintenance and inspection, these are some of the different uses of these technologies in the IIoT settings. So, these are very important, but remember one thing that through this half an hour lecture, you are not going to learn about, how to use the AR and how to use VR.

So, here you are just going to learn about the different features of AR, different features of VR, how they can be used, where they can be used, where they cannot be used. So, these are the things that you are going to get an understanding about. You cannot learn through this half an hour lecture how to become a master of use of these technologies AR and VR. So, this is basically the overall, this is the overall scope of this particular lecture.

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So, let us now try to understand what is AR. So, augmented reality basically, as this name suggests augmented. So, physical reality is augmented with certain information, typically, some computer generated digital images augmented with that kind of information to give a better feeling, better perception to the users, improve perception of the reality to the users.

So, it AR basically will improve the feeling of the reality, the physical reality of the world in which the user is operating. And that improved feeling as I just said can be offered with the help of computer generated technologies, typically different types of images, videos, etcetera. So, these digital elements are added to the actual environment and together we have an amplified environment, where the present perception of reality is improved this is what AR is all about.

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So, some of the key features of AR, it lies in the middle of the mixed reality spectrum. So, we are talking about different types of reality; we are talking about augmented reality, we are talking about virtual reality, we are talking about no reality at all, completely physical environment, we are talking about completely immersed kind of environment. So, AR is some kind of mixed reality kind of environment VR provides mixed reality environment.

So, it provides multiple sensor modalities, which can be visual, auditory or, haptic. Haptic means what? By touch, through touch, basically, you have different sensors which are added to the eye, to the ears, to the fingers, which can give the user an improved feeling. And these users could be any user and in the industrial settings in the IIoT settings we are talk talking about industry users typically. Let us say, a mechanic of a particular machine, an operator of a particular machine can be trained with AR, with the help of these different types of sensors, that I just mentioned visual, auditory, haptic sensors can be attached to that particular user or the mechanic or the operator of an industrial machine. And, different computer generated images can be shown and that basically will give a better perception of the physical environment in which that particular mechanic the operator is operating.

So, they will have improved augmented reality of the actual reality. So, that is going to be generated out of it. So, this is the whole advantage of the use of AR, in industry settings.

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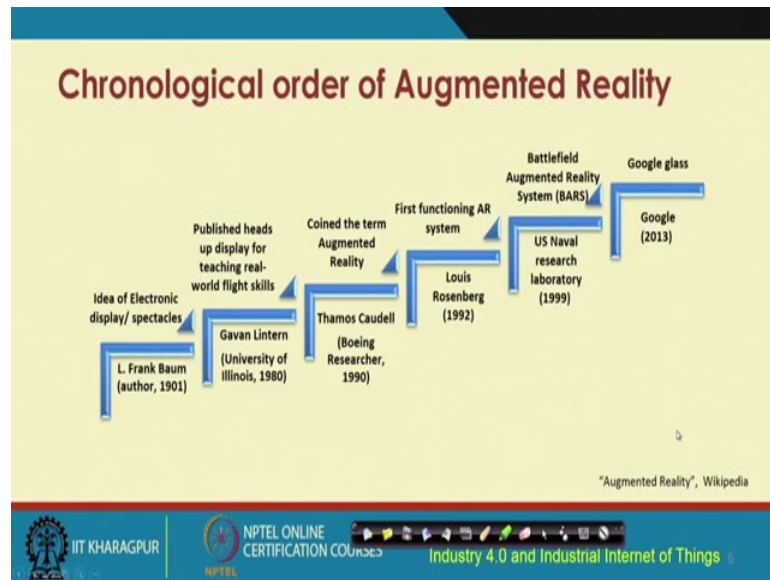


So, let us now go through the history a bit. So, AR has become very popular in the recent times, but it has been there since long starting from early 1900s. So, in 1901 the idea of electronic displays and spectacles came into being Frank Baum basically proposed this kind of idea use of this kind of thing. In 1980s, he published heads-up display for teaching real world five right skills we are done this publication of public publications of this kind of heads-up displays was made available by Lintern.

In the 1990s, Boeing researcher, Thamos Caudell coined the term augmented reality. In 1992, Louise Rosenberg was the first, he came up with the first functioning AR augmented reality system. In 1999, the US Naval Research laboratory came up with the BARS system, which is the battlefield augmented reality system. In 2013 Google came up with the Google glass, which is very popular and everybody knows about it at present.

So, this is basically the overall history of augmented reality. So, it has been there since the last century 1900, early 1900, till recently augmented reality in different forms was there, but now it has become much more popular, because of its use in different industry settings.

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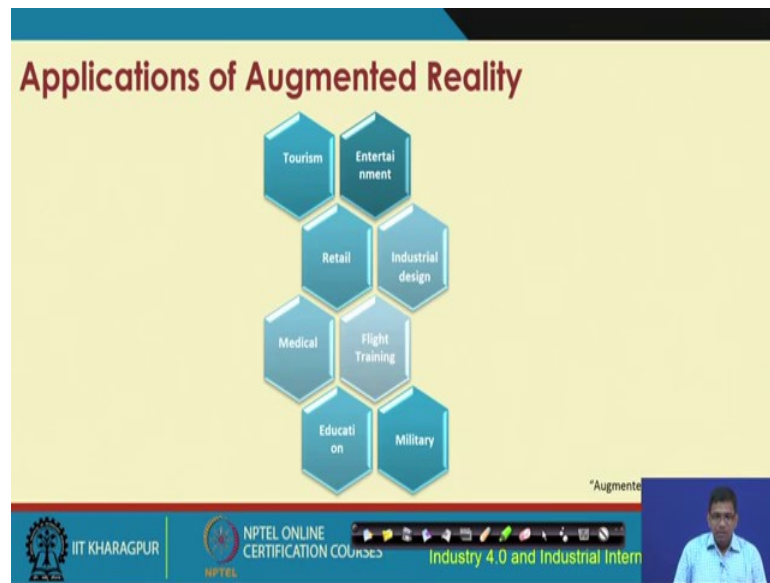


So, different applications of augmented reality in tourism, entertainment, retail, industrial design, medical environments, hospital settings, for instance, flight training, educational, military training and so, on augmented reality; reality has different applications.

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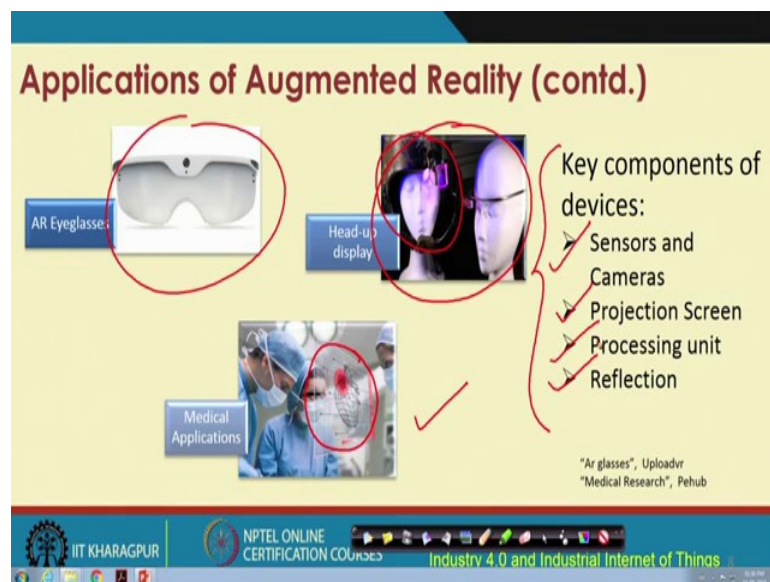


So, here in this particular picture, there are pictorially, the different augmented reality systems are shown. So, on the left hand side we have the augmented reality eyeglasses. This is the augmented reality eyeglass, this is the heads up display as you can see over here the individual is wearing it, the display unit heads-up display unit and then we also

have like medical applications for instance as you can see over here the doctors are performing some kind of a heart surgery and can see using the display, the different aspects of the heart on upon which the surgery is being performed. So, these are some of the key components of these different devices, that are used for AR, there are sensors and cameras, projection screen, processing unit, reflection systems like mirrors etcetera.

So, these are some of the different components that are used for AR. So, let us do one thing, we will now try to some of the key features of how these AR systems work. So, what is important? We have these sensors.

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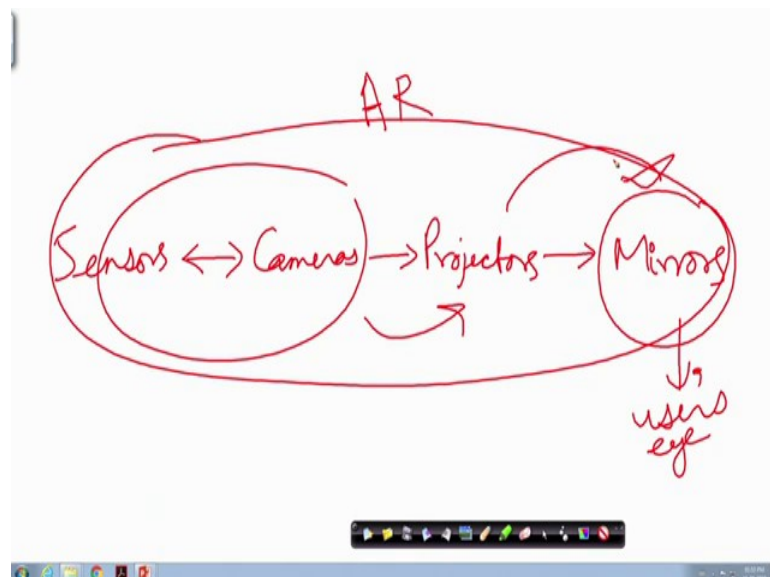


We have sensors; these sensors basically are the ones that gather real world information, then we have also the cameras and these cameras they scan the environment, they collect the data from the environment, from the surroundings. Then we have the projectors, basically, they project the information about the environment to somewhere and then we have the mirrors this is basically the reflection system. So, these are some of the different components of AR and how together the AR systems work. And these mirrors are very important because they can change the orientation based on how the users' eye changes its position.

So, these are the key aspects of AR and how it works. So, sensors collecting data, cameras also basically know projecting in the information collecting the information and then together the sensors, cameras, collecting this information and then sending it to the

projectors, and this projector basically projects all this information and then you have this reflection system, which is the mirror. So, this is how the AR systems work holistically. But as I said at the outset that through this half an hour lecture you cannot become an expert of AR or VR, this is just to get a brief expository idea about how the systems work and what is in there.

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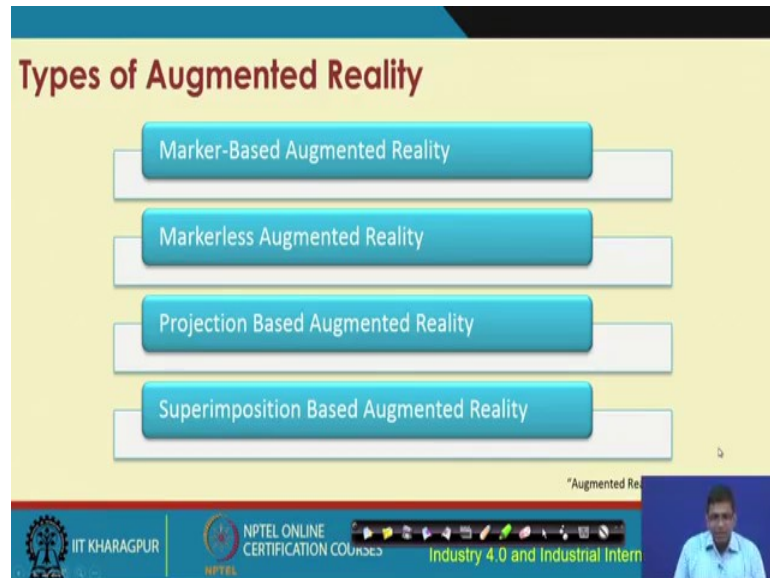


So, now let us look at the different types of augmented reality. We have marker-based augmented reality, marker-less augmented reality, projection based augmented reality, superimposition based augmented reality these are some of these different types of augmented reality.

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Marker-based augmented reality gives an outcome when the reader is sensed by the camera and the visual marker. So, there are two things one is the camera and the existence of marker. So, these markers basically will help in recognizing simple distinctive patterns, which can be easily processed and the camera is well understood what is the functioning of this camera.

The marker-less augmented reality unlike the previous one does not use any kind of marker and these commonly used things like GPS, digital compass or accelerometer, which basically help in offering information such as the location of a person or a device.

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Then we have the prediction based augmented reality, that gives an outcome by projecting light onto the real world surfaces and it allows the human interaction by sending light. And it differentiates between the expected position projection and the altered projection expected and the altered.

So, this is these are very important things these are very important things in expectation and altered projection, this differentiation is very important and is key to AR.

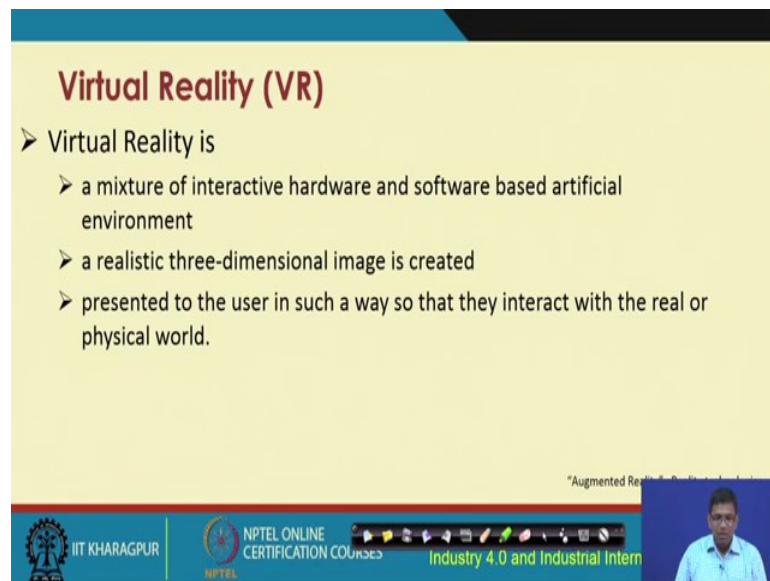(Refer Slide Time: 16:01)

Then we have the superimposition based augmented reality, which partially or, fully substitutes the original view of the object with the augmented view. Here object recognition basically plays an important role and the application cannot replace the original view with the augmented one in this kind of superimposition based augmented reality.

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So, these are some of the highlights of AR and how it works at a very high level, what are the different components of it.

Now, let us look at what is VR and later on, after we have gone through the different highlights of VR, we will see that how AR and VR they compare between each other, what are the similarities between AR and VR and what are the differences. So, VR is a mixture of interactive hardware- and software-based artificial environment.

So, it is an interactive hardware unlike the previous one, here it is interactive and it offers a three dimensional image. A realistic three-dimensional image is created and the user in VR feels that the user is actually present in the physical world, which is being simulated, but is actually not being present. So, it is a virtual environment that is immolated, but the user feels that, the user is acting in the actual physical environment. So, it is a virtual immersion kind of experience that the user gets.

So, this information to the user is presented in such a way that the user feels that the user is operating is acting in the real world or physical world.

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So, the key features of VR are, that it creates and enhances an imaginary reality, this is very important. It is something that is not real in fact, but is a virtual reality, imaginary reality. Then we have it gives the perception of being physically present in a non physical world, this is also very important. It is actually not a physical world, it is an emulated one, a virtual one, but the user feels that user is interacting with the physical world, which is being immulated.

So, it incorporates auditory and visual sensory feedback all kinds of sensors are used in this case also auditory, visual, touch, haptic interfaces are also used. So, user can hold devices and feel that actually the user is holding the device; for example, a user might feel that the user is holding the steering wheel of a car, but the actually its a virtual environment and in immulated environment, there are certain sensors which will give the feeling to the user that the user is holding a particular steering wheel of the car, but actually the user is not feeling. I mean not actually holding the user is not actually holding the steering wheel and he is not driving the car.

So, I hope that this basically makes it clearer to you how it is going to work, not I mean not the technical details of it, but an overall impression about how VR works. So, it

allows the users to get naturally absorbed into the virtual environment. So, this is also very important in VR.

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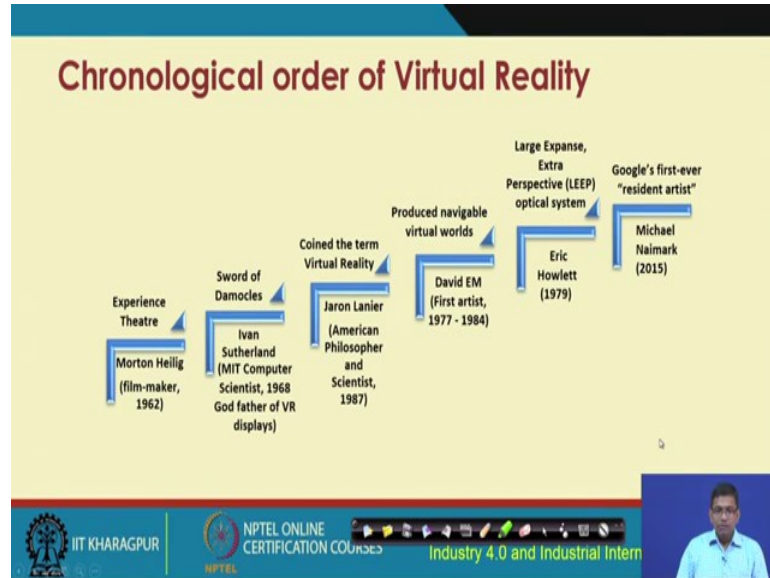


So, in terms of the chronological order of virtual reality, how it has evolved over the years. So, in around 1960s early 1960s the filmmaker Morton Heilig he created an experience theater. So that basically started the works, the initial works on virtual reality, then the Sword of Damocles was created by an MIT computer scientist in 1968 and he is considered sort of like a father of virtual reality displays, then in 1987, Lanier and American philosopher and scientist, coined the term virtual reality.

So, actually the virtual reality the popularity of virtual reality started with this term in 1987, the virtual reality term started in the 1987 and then David EM was the first artist, who died in 1984, he produced the navigable virtual worlds. And Eric Howlett, in 1979 created the leap system, which is the large expense, extra perspective, optical system, and in 2015, Google created the first ever resident artist system and that is a quite popular system, it is a virtual reality system. So, the Google glass we have talked about earlier in the context of AR and Google's in this system the resident artist system is another system which is an example of the virtual reality system. These are quite popular systems in terms of AR and VR being used in our society.

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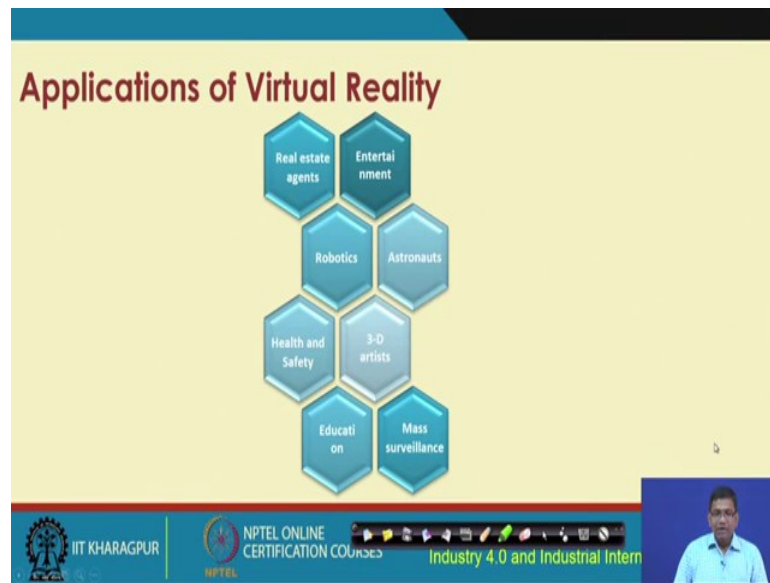


So, there are different applications of VR in terms of used by real estate agents, entertainment industries, robotics, astronauts; astronauts use VR a lot because even before and a space craft is sent to the in the space, the astronauts are trained in the virtual environments, using VR systems, the astronauts are trained similarly for the flight pilots, as well. Fight pilots are also often trained in the using virtual reality systems. And in health and safety healthcare industries VR are used. So, doctors are trained before actually performing a life critical surgery, the doctor can try to practice that surgery in the VR environment. In educational environments it is used by 3D artists, VR are used for mass surveillance also VR has found applications.

So, before going any further, let me just try to show you how overall how these VR systems are going to operate.
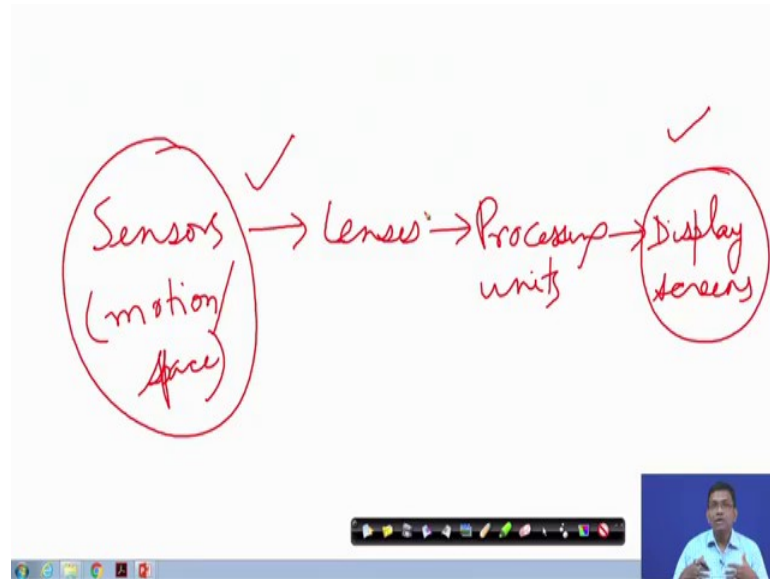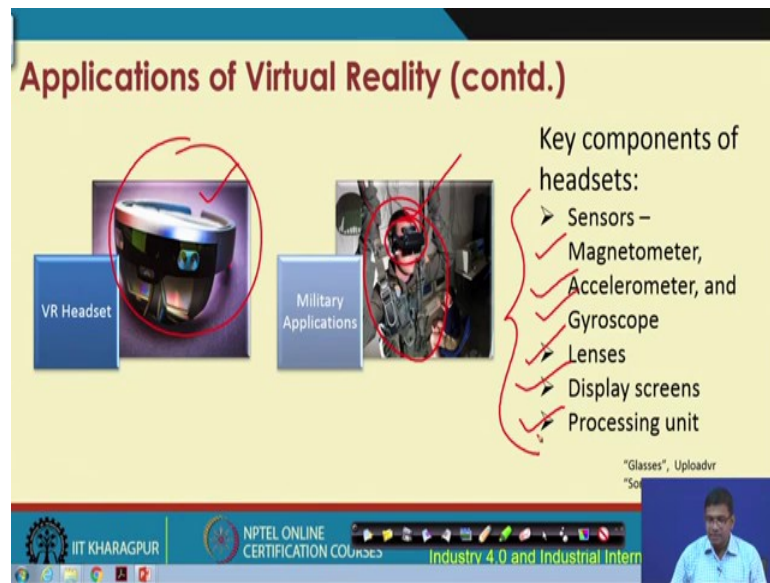
So, here also we have these different sensors here also like before we have different sensors. These sensors can detect the motion the direction in space, motion, space, the position in space, all these things can be detected using these sensors and there could be different types of sensors that would be used. So, then you also have different lenses, which could be used to capture and reshape the image of each eye. Then we have the processing units, which basically will process the data that is captured, then we have finally, the display screens, which basically give the user the feeling of being used in the physical world.

So, these displays are very important. So, these are the overall the different components of a VR system some of the different components, and these sensors are very crucial different types of sensors are used. These sensors, the display system, these are very important and of course, the lenses the processing units processing units are very important and you need to have high end processing units high end processing units are typically used in these VR systems. Because otherwise that feeling will not come if there is a delay between performing a certain action and actually getting the experience the perception if there is a delay, then this VR system is not going to be much useful.

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So, I was telling you about the different applications of virtual reality earlier. So, virtual reality, here we can see few pictures, this is a VR headset that you can see. Here as you can see over here virtual reality sets are being used by a military person to get trained with some combat operation or something very similar. So, there are different components of these headsets are very important. So, these are very important and there are different components of these headsets like different types of sensors, like magnetometers, accelerometer, gyroscope, the different lenses, display screens processing unit, all these as I was telling you earlier these are the important components of a VR system.

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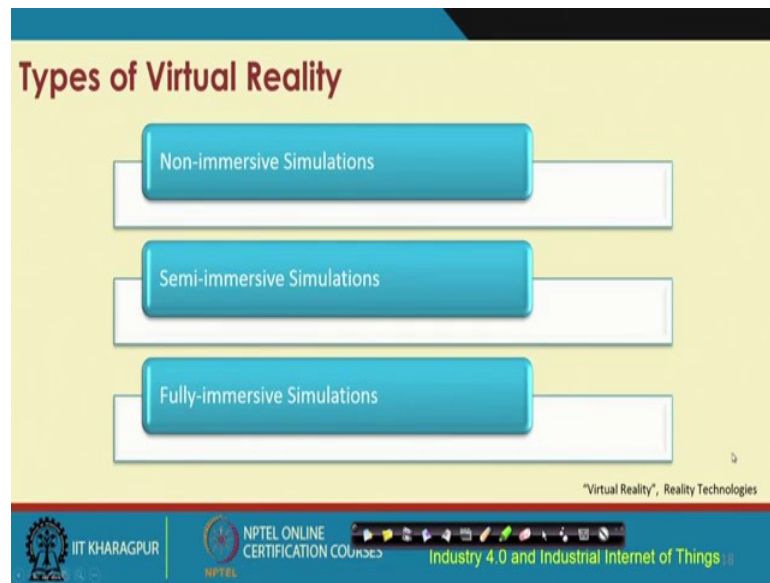


Different types of virtual reality; one is non-immersive simulation, semi-immersive simulation, fully-immersive simulation these are different types of virtual reality environments.
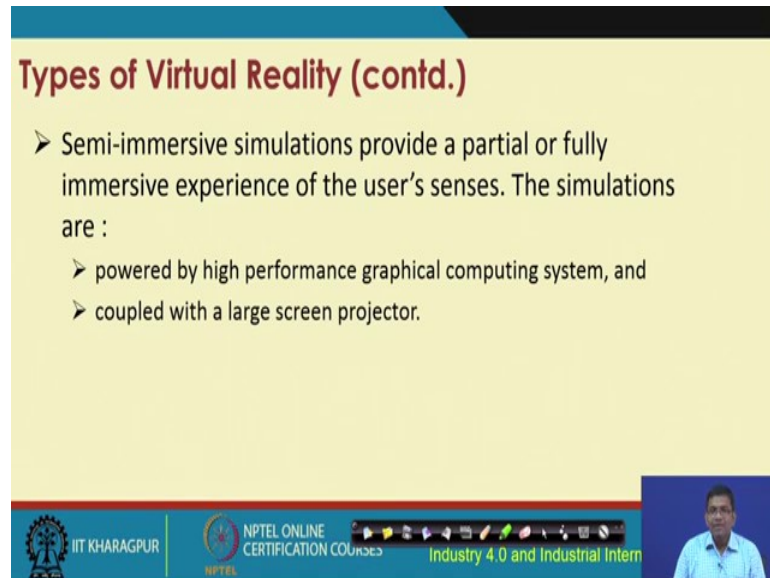
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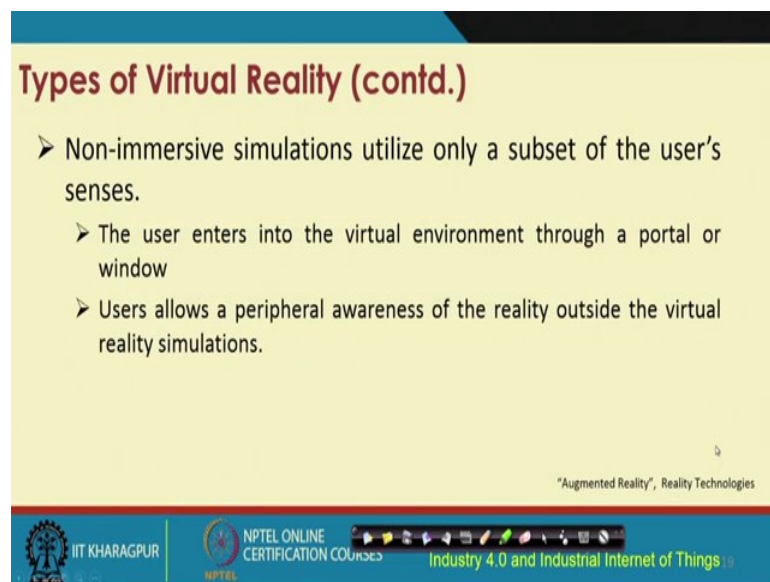


Non-immersive, as these name suggests, the user enters into the virtual environment through a portal or, window and this basically allows the users to have a peripheral awareness of the reality outside the virtual reality simulations. So, this name, as it suggests, non-immersive simulation, basically, utilize only a subset of the user senses not

all of it as a non-immersive. But only a subset of the user senses are used in this kind of simulated platforms, non-immersive simulated platforms.

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Semi-immersive again partly it is not like the non-immersive, but here partly partially or fully-immersive experience, is gathered by the users, through these different sensors and the users use of these different sensors and the senses sensing up through these different sensors, this is what is done in this non semi-immersive simulations. And here basically these are powered by high performance graphical computing systems, coupled with large screen projectors these are some of the things that are used for semi-immersive platforms.

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Fully-immersive is high end basically. Here you have complete immersive experience; complete realistic experience is offered through some simulations to the users, and these simulations offer a delivery of a wide field of view, using different head-mounted displays, motion detecting devices.

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So, let us now having understood AR and VR so far, let us now try to understand the similarities between AR and VR. So, there are many different similarities they are very similar. So, both of these they create new artificial world for the users, both of these

technologies can help create this artificial world. These serve the user with enhanced experiences that is also very similar, there is great prospect in the field of each of these AR and VR in fields like medical science, in astronomy, in flight simulations. There is lot of similarity I mean there is lot of use of AR and VR technologies in these different types of application domains.

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So, this is how these technologies compare augmented reality and virtual reality. Augmented reality adds digital elements to the actual environment. It delivers virtual elements as an encrust of the real world and virtual reality it offers immersive application. It is unlike in the case of augmented reality, what is happening is the physical world is augmented with certain high end ICT features, so that the user gets some kind of improved experience, in improved perception of the reality.

And in virtual reality on the other hand complete or partly partial or complete immersive experience is obtained by the user. So, user feels that the user is there and he is operating completely immersed or partially immersed in the physical environment, but actually it is not a physical environment, it is a virtual environment, in which the user is operating, but the user feels that the user is operating in the real physical world, which is not correct which is not the real one, but a simulated one.

So, it offers a digital recreation of the real-life setting, which one the virtual reality platforms.

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So, here are some of the references that one can go through. So, here I have given you some of the web references, but there are many books on AR and VR, there are many research papers on AR and VR, but I think for this course that, going through in detail of each of these technologies is necessary, it is not easy to understand each of them in detail unless you want to really get an in-depth understanding though about AR and VR.

But then again this will not be right course for you to get the complete understand about AR and VR, you need to register for some other online course on AR and VR. And so, this understanding about the different features of AR and VR systems, the different advantages the different aspects of it, this is sufficient for the industry persons, the learners, to know about how these things can be used in an industry setting to create an IIoT platform in their respective industries. So, with this we will come to an end.

Thank you.