Virtual Reality Engineering
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Lecture - 89
Grand Challenges in VR/AR

Welcome back. In this class we will discuss about what are the grand challenges in virtual reality and augmented reality. We are almost at the you know final stages of this course and in this lecture, we will talk about we will summarize is some of the topics we discussed in the earlier classes and then see what is their challenges in the coming days.

And specifically we will focus on the; you know most difficult concepts, technical challenges in the virtual reality and augmented reality. Like the way we started in the first classes; the whole virtual reality depends on the two pillars of, two pillars like you know immersion and interaction. So, we will look at the grand challenges in the immersion first and then later on the grand challenges in the interaction.

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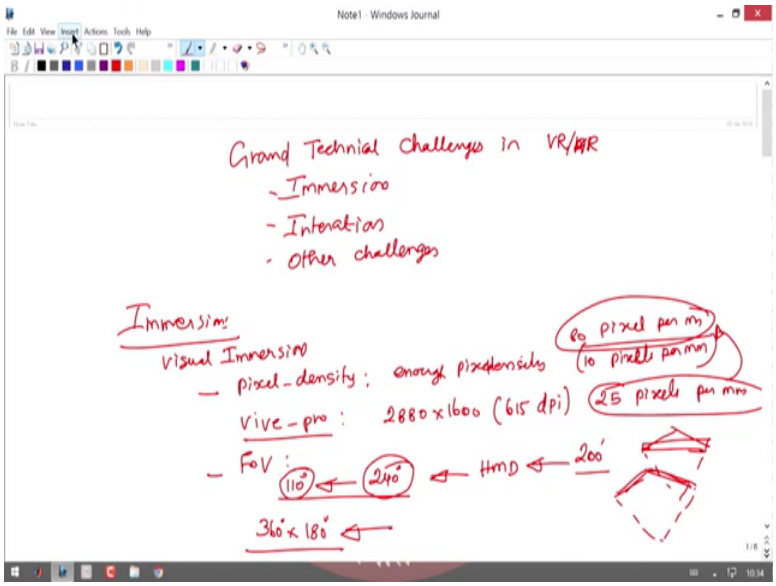

And if there are or few other technical challenges other than this immersion and interactions; we will see them after this interaction and immersion challenges. Let us start with the immersion and grand challenges. We are talking about the immersion, and we are talking about the interaction and then we will talk about the other, challenges, other challenges these are the 3 topics we will discuss as today.

We will start with the immersion; in the immersion we are talking about either the visual immersion, or the auditory immersion, or the haptic immersion, or the any other are sensual immersions. Of course, you know visually immersion is the most important now aspect of the virtual reality and augmented reality we will initially see the visual immersion and then later on go into the other sensory immersions.

As far as the visual immersion is concerned and one of the major challenge we will talk about the visual immersion. One of the major technical challenge is the now pixel density. We talked about in one of the earlier classes what is the required pixel density for the human not to see any of the visualization or pixelizations in the virtual reality displays right.

What is just enough what is the enough pixel density pixel density; in one of the classes we talked about from the physiological limitations of the pixels we derive some numbers and then later on we talked about the limiting resolutions using the perceptual or perceptions. For example, I will we looked at the you know contrast sensitive functions using the contrast sensitive functions. And then we looked at we derived some numbers.

For example, we talked about you know we talked about some 10 pixels, 10 pixels, pixels per mm is a current stage. But what is required it is about you know 80 pixels as per mm alright. These are the numbers are some approximate numbers we got earlier ok. For example, we are talking about one of the latest display, one of the latest gadget VR gadget at in the market is called the you know Vive-pro the professional vive which has got display resolution something like 2880, cross 1600 pixels.

It is almost about you know 6015 dpi, or it is about you know 25 pixels per mm. So, our goal is to reach about 80 pixels per mm. Whereas, we are somewhere near you know 25 we probably it will take about another 5 years to you know get there. So, pixel density is one thing the next major thing is the field of view. What is the necessary field of view? We know again the latest vive pro has a field of view about the 110 degree.

Whereas, as in one of the earlier classes we looked at it that we needed about the 240 degree to give you the feeling of the immersion ok. And also there are some studies which says that you know field of view is very important to avoid the cyber sickness, or motion sickness, or all the other discomfort of the you know using the VR display, or AR displays.

But there are some studies few other very few studies which is saying and which has found that and field of view it does not really matter even those people with 240 degree of field of view the user still gets the motion sickness or cyber sickness.

There are few HMD's which have which have we are aiming at about 200 degree field of view or you know something like this. So, instead of going with a flat display the few novel HMD's in the market they you know they have the you know bend HMD's so that the field of view can be you know increased. So, the flat and displays used in the HMD's can have very can have limited, but the same m flat displays if it has bent then it can increase the field of view.

There are few HMD's already available in the market. So, ideal all full spherical or field of view is going to be now 360 degree cross 100, and 80 degree. So, that will be our aim to you know reach that is going to be the challenge probably we will take about another 10 years to reach to this stage ok.

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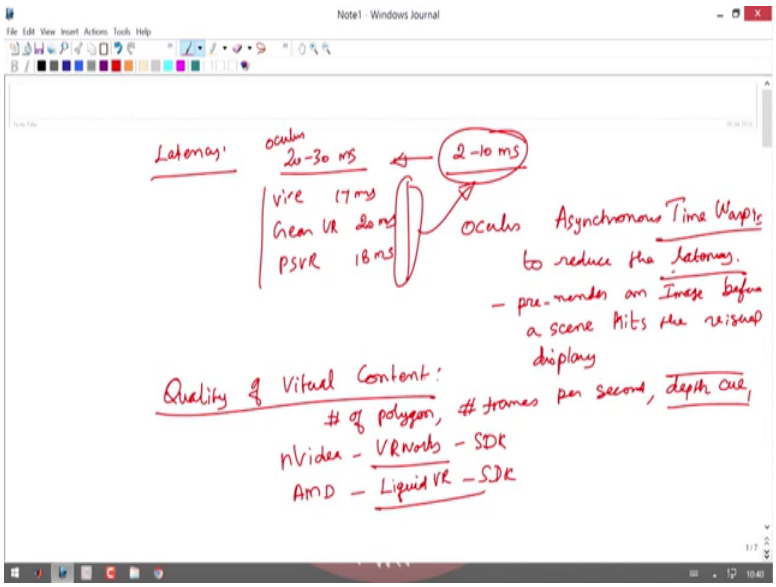

On a third topic is third challenge is the latency, again in as we discussed in one of the earlier classes, the latency is that time lag between and the perception of the motion in the display, if from the that time the user has actually moved. So, there is latency there are few displays which are already in the markets have a latency about you know 20 to 30 milliseconds which is which is not perceivable, but what does actually needed is 2 to 10 milliseconds.

Whereas, oculus for example, has 20 to 30 milliseconds, and vive has vive has about 17 milliseconds, gear VR has 20 milliseconds, and PSVR about 18 milliseconds ok. So, what we really want to do is you know our aim at a 2 to 10 milliseconds. There are the software techniques can be used in order to reduce this existing latency into the record latency. For example, oculus uses some technique called asynchronous time warping, asynchronous time warping. So, essentially we can we can estimate what is going to be the next frame and then render the frame aim ahead ok. So, this is to reduce the latency.

So, this method is to pre render, render an image before a scene hits the visual display so that we can reduce the latency. There are few other techniques it is you know again and what we need to achieve is 2 to 10 milliseconds. And then next challenge is to ensure the quality of the visual virtual content. So, if the quality of the virtual content again it means the number of polygons is the very crude measure number of polygons, or the number of you know the graphics pipeline right, the number of polygons that can be processed you know per second.

There are nvidea graphics hardwares, or amd hardware which is specializing in virtual reality and augmented reality. Specifically they have the SDK ’s, they have the hardware for virtual reality and AR. For example, nvidea has this VR works both you know unity and unreal engine suppose VR works we can use these VR works which is a hardware implemented in the nvidea graphics cards.

So, in the unity and then render many more polygons and therefore, you can increase the number of the quality of the virtual contents ok. A number of frames is another number of frames per second, frames per second is another crude measure of the quality of the virtual content of we are looking at least 50 to 100 or frames per second. Again in all this graphics hardware which is going to help amd has you know liquid VR these are the SDK ’s right.

So, again and liquid VR is supported in the unity, and the and unreal engine you can also you know download it and then start experimenting it. So, then the third measure could be that you know the depth cue, it is very difficult to provide the information of that depth.

The quality of the virtual content is really the 3 d immersive environment, the 3 d immersion comes because of the depth information how well we can render the depth in

the virtual environment is a still a challenge for lot of researchers. And what depth cue is used is you know still an active research. So, depth perception it still on a active research and if the depth is not rendered properly then the user will get cyber sickness very quickly alright.

So, the it will cause lot of health effects which we are going to see later. So, as far as the depth perception is concerned I am going to emphasize another important point which is still at you know grand challenge.

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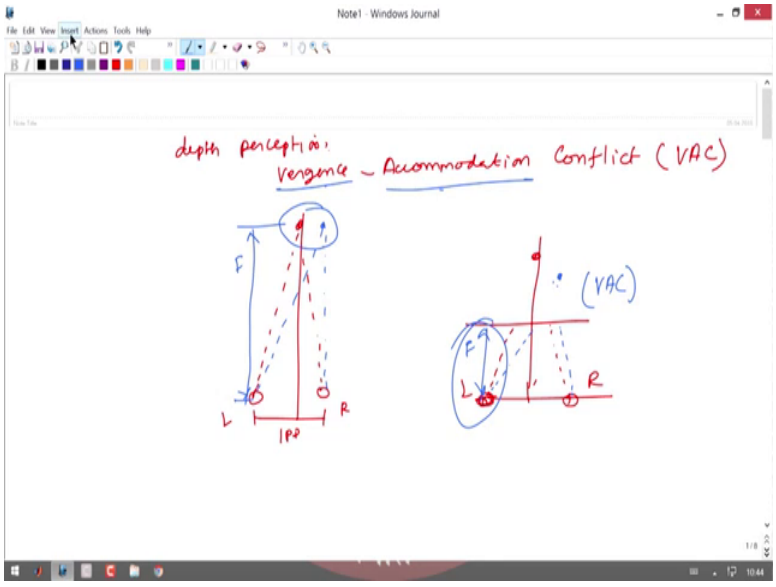

I would call it as depth perception. In the depth perception one of the most important grand challenge is called the vergence, accommodation com accommodation dation conflict, this is called the VAC in the literature. There is a conflict between the virgins and the accommodations. So how are we going to solve this issue that is one of the major issue still it is being researched ok.

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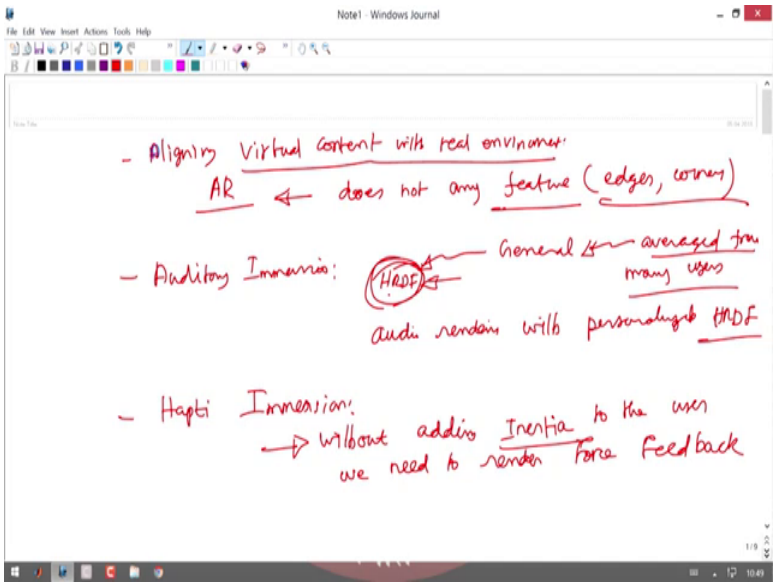

And then fifth major challenge is that at are aligning let me say aligning which will content into the real environment with real environment. So, this is where the AR comes into picture, how quickly that the algorithms what we saw in the last videos about the extended Kalman filter using extended Kalman filter using the monocular slam, or the you know visual slam, or the slam.

In general how accurately how quickly we can and we can and align the virtual content with a real environment. In most of the situations the scene does not have it does not have any features the features in the sense there are no edges, there are no sharp edges, there are no sharp corners whereas, the slam assumes that there are edges and corners.

If the scene does not have any sharp edges it is all very curved very nice features. Then you know feature extraction is going to be very extremely difficult when there is no feature possible then simultaneous location a localization. And then mapping is going to be extremely difficult it is still a challenge it is still an active of research as far as the AR is concerned. And for a general scenario where there are no edges and corners what kind of other features general features can be used for slam it is a still a challenge so that is about the visual immersion.

Similarly, we have this auditory immersion. We are talking about you know how to give the how to provide the real immersion auditory immersion and in the virtual reality. Again yeah you know very high quality of HRDF, if is necessary for very good sound

rendering. But this HRDF which most of the 3 D audio rendering algorithms are using is for general user it is all you know average user averaged from many users. Let us say averaged from many users, but individual users we will have a different HRDF whereas, this is for the you know general user.

So, audio rendering, audio rendering with personalized HRDF is going to be the main challenge in the coming days. So, we do not know whether this is important, but in order to improve the immersion of a audio auditory immersion effect as this may be you know important. So, similarly we can talk about the haptic immersion. So, the haptic immersion again in as we saw in earlier classes as without with without the feeling of wearing heavy objects, we should be able to give the touch feedback.

So, without adding inertia to the user or we need to render to render force feedback. So, as of now there are gloves available, there are cyber gloves available which adds lot of weight to the users hand. And therefore the inertia and therefore, it changes the feeling of immersion. So, ideally you know without any of these gadgets in the hand and can we feel the force feedback that is a challenge.

How do we feel the force feedback it is still a challenge, most of the virtual reality without force feedback is not much useful the user feel the realism is missing without their haptic feedback. So, the feeling of the virtual immersion, and auditory immersion, and on the haptic immersion it is all very important.

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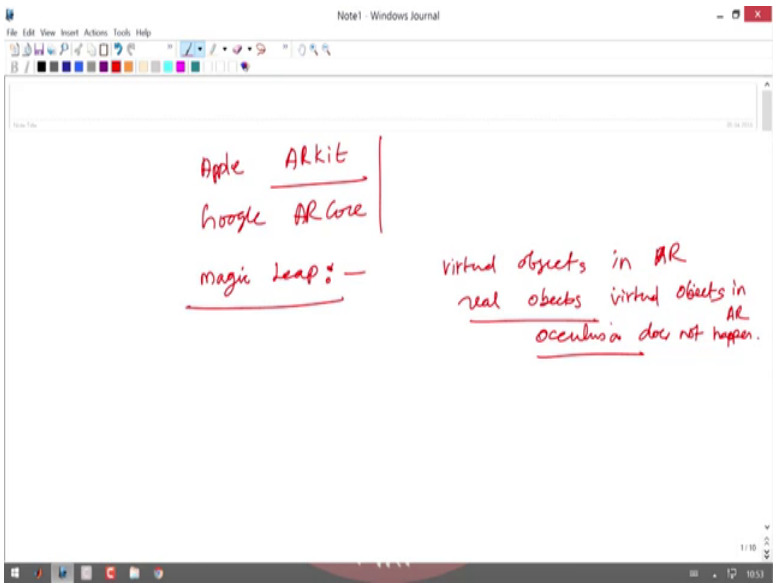

There are recently apple has come up with some SDK ’s, AR kit which talks about specifically you know improving the visual immersion, as well as the auditory immersion, as well as the haptic emotions, you can take a look at it. Similarly Google has also come up with another SDK called Google AR core.

So, if you are not aware of these things and so I am going to request you to pause the video for a minute and then you know get yourself exposed to those kits which may be very important and in the coming years. So, there you can see that in order to improve the immersion there is a war between the major are gains software gains and in order to come up with a you know better SDK ’s right ok.

Apart from this there is also recently you know there is also magic leap. So, magic leap is one of the one of the AR glasses where it is much lighter than the hololens Microsoft, hololens and it has lot of other features. The special features I think the specification itself is not at out there at. Again and you can look forward to you can look forward to see advanced features in the magic leap ok.

One of them one of the you know very well talked about features of the magic leap is that at if there are virtual objects, virtual objects in VR, in an AR. And there are some real objects it is in the there are real objects which is behind the behind the virtual objects or say in front of virtual objects, virtual objects in the AR real objects.

Then and the occlusion does not usually happened occlusion does not happen where is that is supposed to happened. So, magic leap says that at it they demonstrate that the virtual objects in front of or behind the real objects the occlusion is taken care very well. Whereas, in the other kits say AR kit or AR core or that is not happening over here.

And also it is a magic leap is a very lightweight and it is talking about. So, that is about the that is about the sorry let me stop here so that is about the immersion and challenges.

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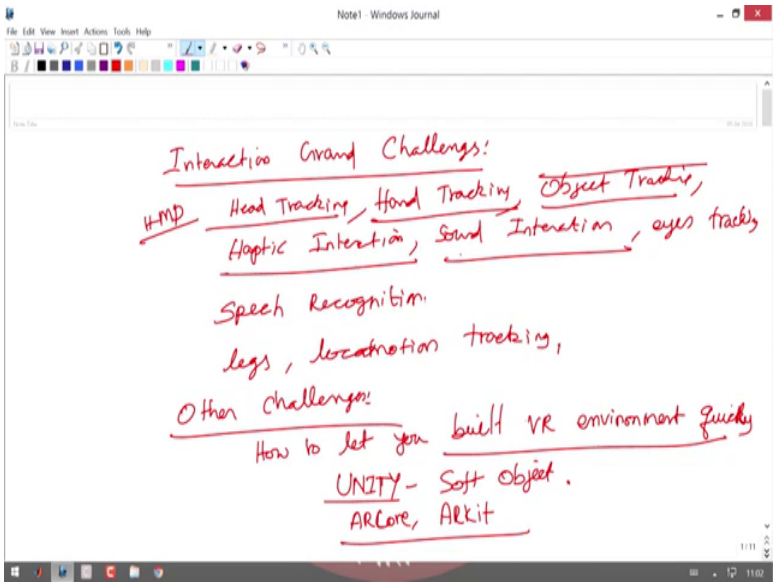

Now let us look at the interaction challenges of course, the interactions we have talking about the haptic interactions though or the auditory interactions, or the visual interactions head tracking. So, head tracking is one thing, head tracking hand tracking hand tracking and you know objects tracking in the virtual reality object tracking and then we are talking about the you know sound interactions, haptic interactions, or sound interactions, or sound interactions.

So, in each of this we can talk about the head tracking itself is a this is lot of challenge the HMD's we have talking about has to be very light right as of now of the HMD's you know ways much more than the 1 kilogram. Whereas, if the HMD is more than 1 kilogram we cannot wear this as for a long time even if you wear long time you are getting used to the weight in your head.

And when you come out of the virtual reality you get you know cyber sickness you get to use to adapted to the adapted to having lot of weight in your head. It is suggested that HMD weighs much less than 1 kilogram in the future the all the big companies are running towards making this magic leap kind of devices it is like a sunglasses it should not be much more than the sunglasses.

But are still we should be able to render virtual object in the augmented reality we should be able to experiences that is the directions we have looking at it as of now of the HMD's

weigh by 1 kg. So, imagine how much the sunglasses is being how much is this the current HMD's are weighing that is a you know long way to go right.

Hand tracking again hand tracking without any of the gadgets added to it is again a challenge. And there are challenge is there are you know there are techniques available say leap motions, or you know real sense which is tracking the hands, but again reliably tracking is one of the important challenges.

Now what is the accuracy of this hand tracking using this leap motions under are real sense is again the big challenge. How do we improve the accuracy of hand tracking not only hand tracking even the finger tracking. So, because in the virtual reality environment it is not just you know moving around it is not just you know navigation. And in the future there are many applications will come where we are precise now a finger or hand movements is necessary.

For example, in the skills training so hand tracking precise hand tracking is still one of the important challenges over here. Again object tracking there will be many objects in the real objects in the environment and this objects should be tracked and the corresponding virtual objects should be updated again an accurate object tracking is important.

So, vive tracker has solved this problem some way, but without adding inertia to the objects. For example, I have a very light objects in that light object we cannot put a you know virtual sorry vive tracker which is the itself is having more than and a couple of 100 grams right. So, if the object itself is you know 10 gram and if you add the vive tracker then it is killing the immersion object immersion of interacting with the objects so that is again a the big challenges.

As I mentioned haptic interaction is going to be a big challenge without adding inertia to your hand, without adding extra gadgets in your hand, how do we give the force feedback that is still a challenge ok. And then sound interaction also we talked about. So, a speech recognition is still a challenge speech recognition most of the speech recognition engines and implemented in virtual reality or a AR environment is trained using one particular user. But now it has to recognize is entirely new, new voice.

So, that is going to be the you know the future challenge if you have lot of data, maybe you know machine learning algorithm much better machine learning algorithms can be used to recognize a speeches of a entirely new user that is going to be it is still a you know research topic.

Of course, we have talking about the eyes tracking also eyes tracking the foliated rendering and we talked about in one of the earlier classes ok. Locomotion, legs, and locomotion tracking locomotion tracking is again and a big challenge, there are few gadgets, or few products available which will let us you to walk around.

And, but still there are challenges over here it the gadgets are very big but without adding you know much inertia to the legs, or restricting your motion. How do we give a immersive effect of a locomotion, and it is a challenge. So, you can see that there are many more interaction and challenges. Apart from those interaction challenges there are other challenges.

The other challenges something like this is how to let you build here virtual reality quickly how to let you build well VR systems, VR environments, it is quickly or easily quickly. So, there are the unities and unreal engines which you are already aware of it they are solving this problem. Their aim is to help you to build virtual reality systems quickly, but there are challenges ok.

For example, if you look at the unity there are something is not possible for example, soft objects rendering soft object is still a challenge a very simple soft objects you can render it. But now very complex soft objects which is necessary for some specialized applications is still a challenge. For example, soft objects interacting with the soft objects in the unity, again it is going to be a challenge whereas, unreal engines and soft engines soft objects may be possible, but there are other challenges in the unreal engines.

So, coming up with the you know SDK unity or unreal engine in a like SDK with lot of features at the same time let us you build the virtual environment quickly is a challenge. So, it can restrict the features so that you can you know fasten the development at, but having full features many features at the same time speeding up the development is a still a challenge.

So, that is where this apples AR kit, and the AR core is a AR core, or AR kit it is all helping you to build you know much better systems. So, one more challenge as far as the virtual reality or AR system is concerned is that the computer systems which is you know doing that number crunching. So, much of number crunching along with a graphics card hardware has to be very small.

So, right now only the desktops can do it and the augmented reality Microsoft hololens which is bulky can do only a little bit of a number of processing number crunching. And in the feature the if the the whole device the computer itself has to be very small.

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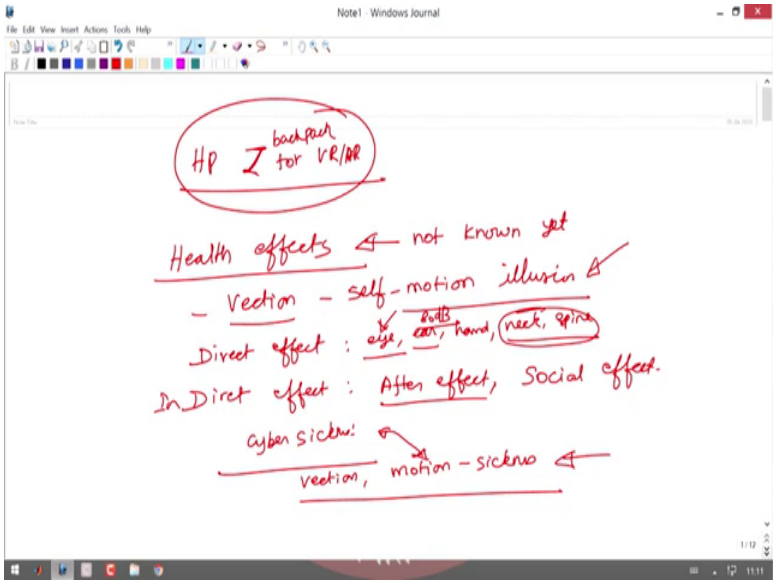

For example, recently HP has come up with the a system called Z for VR, for VR, and AR, so it is a actually a VR backpack actually backpack version.

So, the HP machine the Z version of the HP mission, can be you know put it in through the you know backpack and that system can be connected to your oculars or vive which does not need a long wires to connect to their desktop. Therefore, it does not restrict the you know movement of the user. So, development in the computational side it is again now big challenge how small computational all systems and its you now can be made to help the VR, AR set up is the is such still a challenge ok.

And the most importantly and finally, we are we are talking about the health effects. As far as the health effects is concerned in VR and AR these effects are not completely

known yet not known yet. So, one of the most important health effect is the vection, the feeling of the illusion of self motion, self motion, and illusion. Some virtual reality scenes or AR scenes will induce the motion of self motion which is going to be you know causing the nausea or you know in total which is going to cause in nausea or in total it is called the you know cyber sickness.

So, all the health effects we can call this is a direct effect we can classify into either the direct effect, or the indirect effect, and their direct effect or a indirect effect. In the direct effect we can talk about the effects to the eyes, the ears, and the hand, and neck, and hand, and neck, or the spine all those details we can talk about. In the in the indirect effect we can talk about after effects we are talking about the after effects after using this virtual reality so what are these you know problems.

And then and you know we can also talk about the social effects, effects of the virtual reality and the and the augmented reality. So, as far as the eye is concern. So, eye strain can be a major issue if you are using this virtual reality displays prolong and the flicker, and the glare, and the improper death they can all strain the eyes, eyes strain is one of the major challenges.

So, how do we ensure that a particular virtual content is not straining the eye of the particular user that is still a challenge ok. Poor illumination can be a problem, poor contrast can be a problem. So, eye strain is one of the major challenges. In fact, the radiation coming from the LED's that can and cause you know cataract is in the effects or still not known and the fizzy physiological effects is still not known, but there are possibilities ok.

There are ocular stems symptoms for example, unstable binocular vision, or reduced to visual acuity these are all the problems that can cause into eye. Similarly the ears also there are some physical effects for example, walkman effects if you are exposed to high volume of sound for long time then and there is a loss of hearing.

For example, more than 80 decibel if you are exposed to then that is there is chance of a loss of hearing ok. And if you are using the head mounted displays which is varying which is the heavier than 1 kg for very long time, then there is a chance of a neck and spine injury. There is a whole lot of you know cyber, there are a whole lot of effects known as cyber sickness. Of course, you know vection is one of the most important in

cyber sickness at the headache or you know blurred vision or the combination of all these things and that there is a motion sickness.

This also the cyber sickness is also you know sometimes called as the motion sickness as vection is one of the important things. How do we avoid vection what kind of technology that can help us to avoid the vection is still a research topic. And then still we are still looking for solutions to avoid the vection in the virtual reality probably it will take another 5 to 10 years to come up with a good solutions to avoid the vection.

There is a conflict between the vestibular systems on the visual systems. How do we avoid this conflict? There are some systems and which stimulate the vestibular systems whenever there is a self motion occurring. So, these are all invasive techniques which is again we will have long term effects it is health affects which is not suggested ok. We are looking at the non invasive techniques at the same time I am avoid these vection that is a still that is a challenge ok.

As far as the after effects concerned we are talking about the adaptations. So, if you are using the virtual reality for very long time then and you get adapted to it when you are coming out of the virtual reality. You tend to continue feeling the virtual environments for example, motion. So, your brain is highly adaptive and it is early made of plastic.

But the advantage of or disadvantage of this plastic nature of the your brain is that or after prolonged use of the virtual reality you still continue to feel as if you are in the virtual reality ok, it happens even for several hours this after effects continue for several hours ok. So, how do we avoid this after effect is still a challenge. So, some of the effects is going to be you know head spinning or postural instability or reduced to hand eye coordination or vestibular disturbances these are the you know after effects ok.

And then finally, we will see what is the social effect the social effects in the virtual environment it is so stunning, the virtual content is so, compelling and what will be the effect of social effects of this very good highly quality virtual contents ok.

If the user is practicing violence say in a game of a shooting game ok. How will it at you know how will how will it help or you know version the psychological feelings of this user.

What is the effect of virtual reality environment on the psychology of the user practicing violence, or it can be used to improve the positive aspect positive psychological effects of the user. Such as you know cooperation, or friends friendship, or relation, or love these are the positive social effects of the in virtual reality.

So, it can either have the positive or negative effect any technology it will have both positive and negative effect, but you know what the social effects of the virtual reality is still not known. Probably we will take a couple of years to understand what is the social effect of this technologies.

So, I hope I have given some overview of or what are the grand technical challenges as far as the you know immersion is concerned and the interaction techniques are concerned. And we talked about little bit other than other than the immersion and interaction techniques. And finally, the health effects specifically the social effects they all indirect effects we looked at it.

I hope some of you who are listening to these lectures as will be able to address these challenges in the coming days and then make us proud we will stop here.

Thank you.