Virtual Reality
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Lecture - 2-1
Bird's-eye view (hardware)

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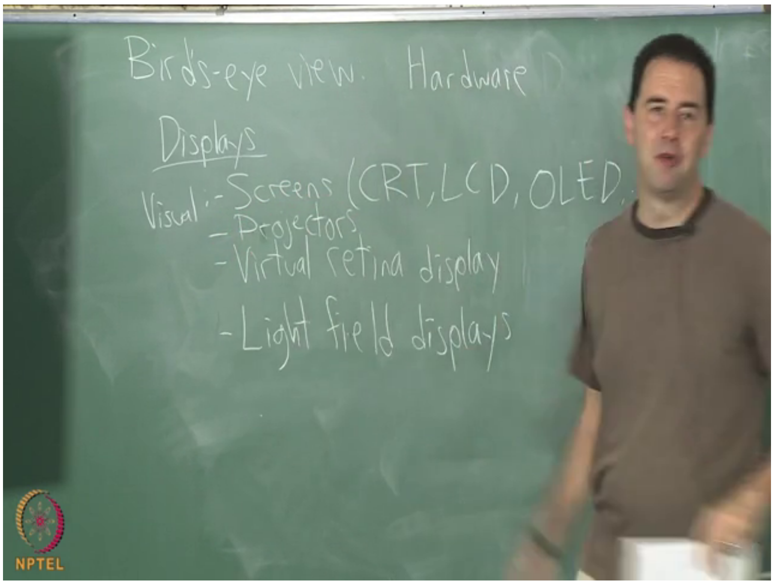

So, again this is part of the bird's eye view. And I wanna talk about hardware, all right. So, one thing talk about is displays. So, again we have talked about screens for I should pay visual. So, examples are visual. So, we could have screens like, maybe going back to cathode ray tube monitors, all right. I think you are old enough to remember those at least, right. LCD's plasmas I do not know organic LED's so forth. And maybe you might want to involve lenses in some kind of optical system, if you are making a head mounted display out of these. You can get a little more exotic, and do virtual retina display. There is a lot of work on this going on in industry a lot of it let us say behind closed doors.

So, lot of research lot of prototypes being developed with virtual retinal displays, essentially just take a tiny projector, and just project images directly onto your retina, but of course, they are still going through the lens of the eye. So, it is not exactly same as you would think, but at least you are not trying to just simply look at some pixels, and deal with whatever the relationship is between that, and how it falls onto the retina, you are directly considering what information should be presented to the retina. So, that is one possibility is also an interesting and exotic family of display is called light field displays, you can research these on your own light field displays I will not cover these things.

In this case, rather than presenting the information on as a 2-dimensional projection, they try to capture the entire field of light within a 3Dimensional region, and this is very helpful so that when you rotate your head and your eyes are translating through space, or you move your head around inside of a cubic let us say volume. Then you can adjust the information that is actually presented to your retina in terms of where your position and orientation are in that space. So, you capture the entire light field using something like say a plenoptic camera array or some other kind of device it is also very difficult to do, and then present the entire information in some way so that you can in real time take into account these small motions and present the entire light field. So, that is another possibility. And I guess somewhere in here I should have mentioned, let us say projectors, I will put it up here by screens. In fact, I probably should have put it first, we had movie projectors for a long time going all the way back to the beginning a film, like the like the train pulling into the station from 1895.

So, maybe projectors should even be first there. For audio so, that is visual just think about displays again.

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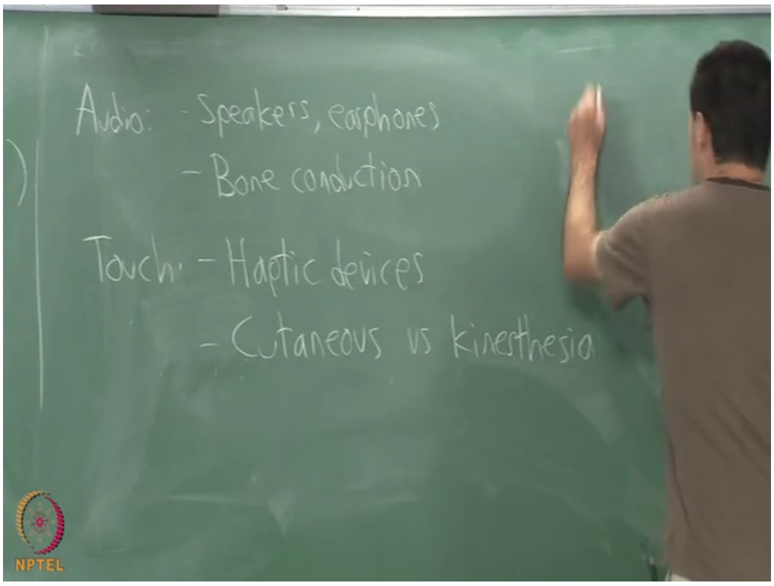

So, audio speakers or earphones; which are small speakers. You can fool your audio sense by bone conduction as well right, some bone conduction audio techniques, touch so, there are what are called haptic devices. And you know, would not I would not have time to cover this these in the class, but couple of general categories which are worth considering about is cutaneous versus kinesthesia. So, nice way to divide these up. An example of the first one is maybe I just get some kind of vibration as a kind of feedback, right. A rumble pack in a in a in a game controller would be an example of that, or maybe my emotions actually get blocked I feel a resistant force, there may be a robot on the other end pushing back at me, all right. And providing the right force to that it feels like I am touching a wall I keep getting stopped every time I put my hand out right, but maybe a robot hand that is touching mine, let us say.

So, that would be an example of kinesthesia. So, so you can provide this kind of feedback as well. And as far as going into smell or taste or vestibular stimulation I guess I would not include too many examples of that, but there certainly is ongoing research on those as well providing the right chemical feedback to trick your sense of smell or taste. And there is electrical stimulation of the vestibular organ that is possible. But I do not recommend trying it. So, it is very painful from what I hear, all right. Other hardware you might think about inside of hardware, other hardware of course, we have computers on use and we have graphics processing units let me just kind of you know.

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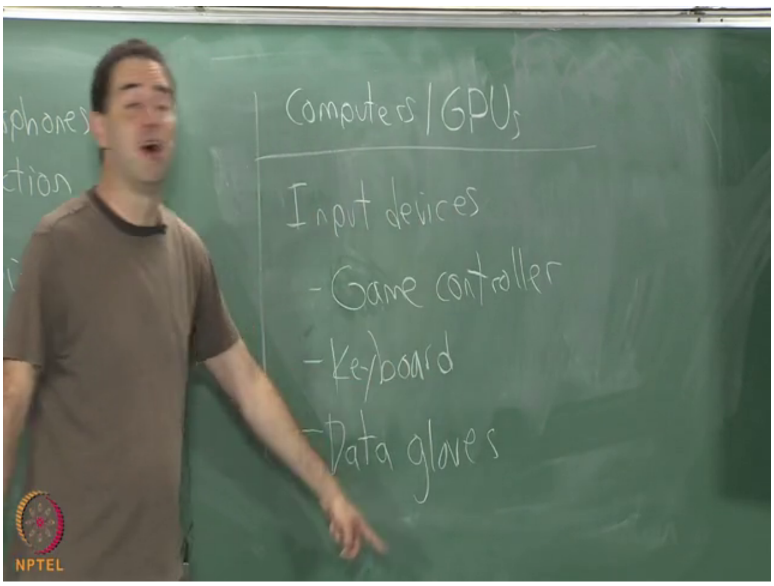

Just to kind of list off everything computers and GPU's inside of there. So, let us say CPU’s and GPU's, and I should also say that there are inputs, and in this case maybe something like a game controller, keyboard we talked about data gloves been around for a long time.

So, lot of interesting research and development going on this part by the way input devices for virtual reality is a lot of open work to be done. There because once you put on a virtual reality headset it is like a blindfold, and probably the last thing you want to be doing is just feeling around for the keyboard, all right. So, how can you do things? Like, suppose you wanna sit and write software inside a virtual reality. You just want that to become your desktop, all right. So, how do you do that how do you enter data fast enough and in a comfortable way, and interact with your environment. Is it going to be a keyboard and mouse? Or is it going to be something else? One more bit I want to say about hardware is what do we use for tracking. So, tracking is going to become very important as I talked about in the case of a head mounted display, when you turn your head you have to get the visual information to update correctly.

So, that it really looks like the virtual world or this alternate world is responding appropriately to fool your brain. So, tracking becomes very important; and the more portable the device gets or the closer it gets to the actual sense organ, the more kinds of tracking you need. If I am in a cave system, I can see my entire body as I walk around all, right? If I put on a virtual reality headset and look down it do not see my body. So, I have to invent a body, how do I do that? Well, I can track my body and then bring that into virtual reality, but that is a lot of work, it is very challenging. It is reasonable as a class project, but it is very hard to make it a 100 percent reliable and accurate.

So, these things do not work very well they look great they make great demos, but very, very hard to do that. You could put on a motion capture suit a full body suit with markers, gets a lot better than, but if you are going to do that much work, why not just build a cave system. You know, so it is very interesting kind of problem. So, I want to talk about tracking, and this will finish off the hardware. Where is my chalk? Let us see leaving it there, all right.

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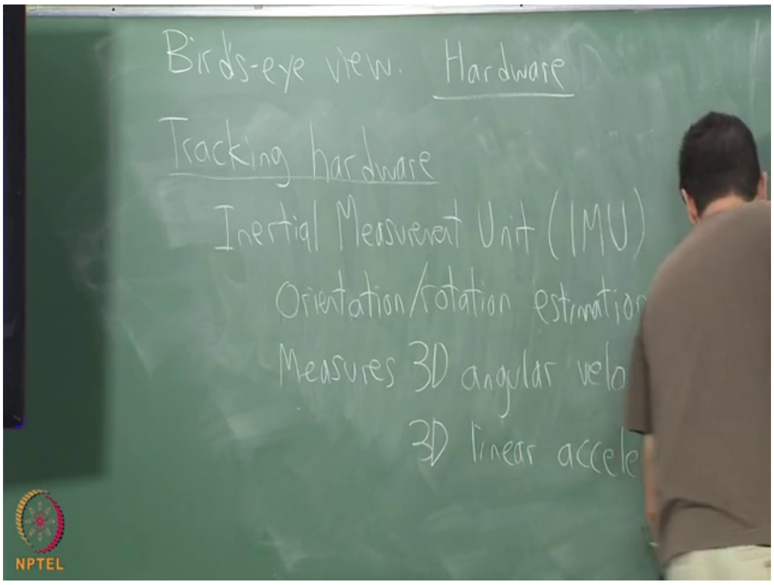

Tracking so, you call this tracking or estimation or filtering. So, people in electrical engineering will tend to use words more like that. One of the most useful components is the inertial measurement unit people call it IMU.

So, IMU has been around for a long time they were originally designed for navigation, especially useful in aircraft and spacecraft. So, if you fly on if you have flown on airplanes before almost certainly there was an IMU on board. Usually a rather large mechanical device; so the purpose is to provide orientation estimation. So, these are used for orientation, orientation or rotation if you want estimation. So, that is their main design. What it measures is 3D angular velocity and 3D linear acceleration. So, the angular velocity measuring part is usually called a gyroscope.

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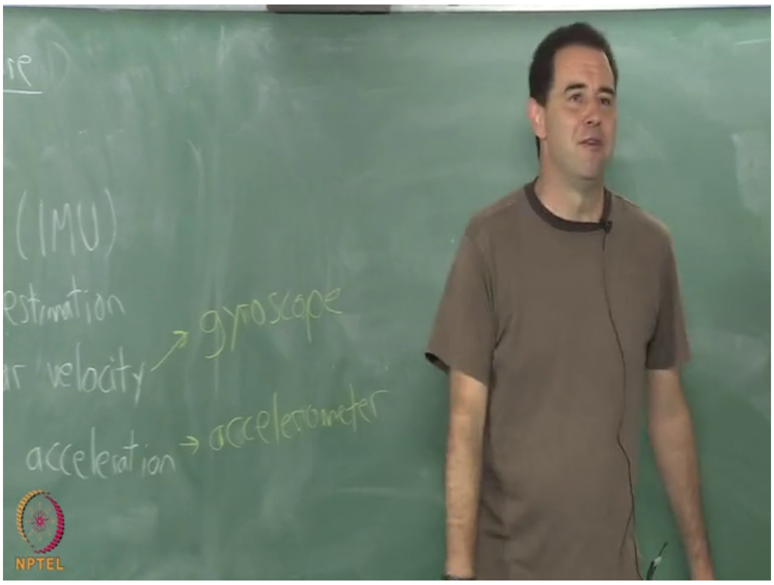

Sometimes people refer to the entire inertial measurement unit as a gyroscope I think that is not quite right. And this part is called appropriately an accelerometer.

So, this measures linear acceleration, but it is also measuring acceleration due to gravity. Because there is no way to really separate, true linear acceleration with respect to the fixed earth and gravity in in a natural way. There is no natural way to separate that you are always measuring the vector sum of those 2. It is as if we are all on a rocket ship right now accelerating that way at 9.81 meters per second square which is why we are all stuck to the floor all right. So, that acceleration is always being measured as well all right. So, we have the inertial measurement unit, the interesting thing that is happened in this technology is that our smartphones have IMUs inside. Mainly so that you can play these apps where there is a ball rolling around or I guess it is designed so that it tells you whether or not the screen needs to be reoriented; which frequently seems to fail, and it very often fails because you are moving while orienting and this linear acceleration of the device is getting confused with gravity it is all kinds of issues like that.

But these started appearing in smartphones they became very, very cheap mass produced on the order of 100s of millions. And now you can just take those and put them inside of virtual reality headsets. And you have an IMU to use, and does not cost very much money at all right. So, so it can be mass produced you can also put them inside of ear phones as well. So, this is great you can stick them on robots. You can put them all over the place to estimate orientation. So, that is one of the greatest enabling technologies, and one thing that Is very closely related to the inertial measurement unit, and it is sometimes considered a part of it is magnetometer.

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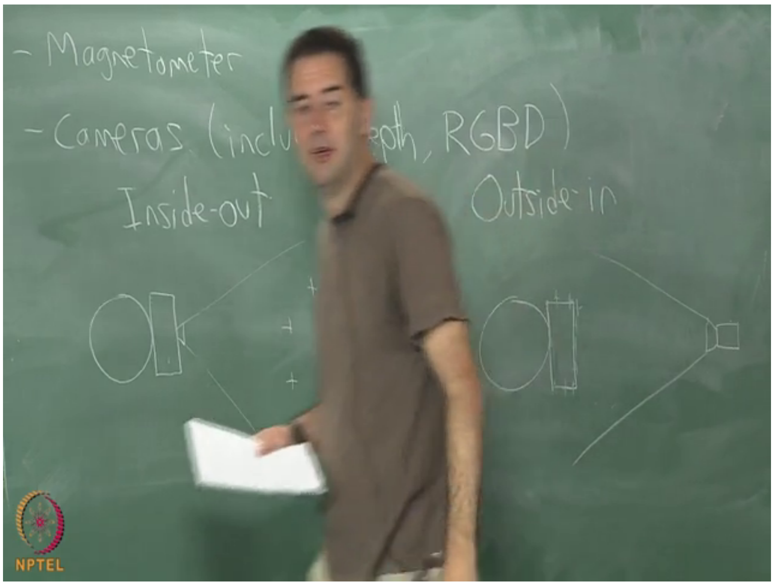

Which measures magnetic fields 3D magnetic fields, you can sort of think of it as a compass, but it is not exactly a compass it is going to measure the vector sum of the earth’s magnetic field and whatever other magnetic fields are around, in the building let us say. Or on the circuit board that contains the magnetometer.

So, it is just generally measuring magnetic fields, that is also used to provide orientation information. Other hardware, cameras have become quite useful. You will notice on the dk 2 oculus dk 2 used in the lab. There is a there is a camera. So, that is being used as part of the tracking system as well. And when you use cameras there is generally 2 different kinds of ways of doing tracking. The names are inside out and outside in. Honestly, I if got these I thought it very confusing it took me at least a few weeks to keep them straight. So, I do not, but these are the terms that are used. So, in the inside out case. You are this is a top down view you are wearing a headset, and there is a camera on it here let us say. And then there are some markers in the physical world I will draw markers as pluses features or markers. So, they see these markers.

And so, based on how these markers appear to the camera, that is fixed to the headset you can figure out where you are at. These markers could be engineered or it could be using natural features from the environment. If you engineer them yourself, then you get very accurate very reliable performance. If you just extract them automatically it makes a fun project, but it is an interesting demo maybe, but it is very hard to get perfect accuracy and reliability. Or very, very high accuracy and reliability like this. But nevertheless, either way this is inside out, the other way is outside in which is what happens in this oculus rift dk 2 case, can you have the head looking straight down. You have the headset on, and then there is the camera out here looking. And so, these features draw them in another colour here. So, we see them are on the headset itself. In the case of oculus rift dk 2 that you will use in the lab, these are infrared LED's that are embedded inside of the headset. The plastic is infrared transparent.

But in the visible spectrum it looks black. So, you can not see the LED's, but they are inside of there. So, in this case it has markers. So, this is outside in other words the camera is outside looking inward, and in this case the camera is inside the headset looking outward. So, these are ways to use cameras, and we can talk about the technology of doing this tracking later in the course. I will spend some time on that. And of course, you can add to the cameras depth information. So, you can have what are called you know including depth like information provided by the kinect, using current technology to give you what are called RGBD sensors, all right. Giving you colour and distance information. So, there is cameras for that and those are going to be very important in the coming few years as the cost of those goes down. The reliability goes up the accuracy improves, there is going to be more and more technologies that use depth cameras for various kinds of tracking. So, you put all this together there is also more methods that use electromagnetic fields or magnetic fields that are generated by a base station, and you can do tracking that way. One thing to think about throughout these tracking technologies is what do you need to track. Track your head, track your eyes, you want to track your entire body?

Do you want to track an entire room full of people? Whereas, all kinds of things you think you want to do. And you do not necessarily, have to do that for example, I am giving a lecture today. And I can only look at one of you at a time, right. If we were all in virtual reality doing this lecture, I could be looking at all of you at the same time. They each one of you would see me looking directly at you, right? So, you do not need to have my head tracked perfectly. I need to have my head track perfectly I guess to have the display correctly. But I do not need to have where my eyes are looking tracked perfectly in terms of what you see I could just make it. So, that I am always looking at you. So, that you are always paying attention to me. And you get the feeling individually that that you are being looked at, but really, I cannot possibly be doing that.

So, there is cases where you do not want to provide the exact information that is going on in the real world. So, you really have to think about these things carefully, and there is always a cost involved an accuracy issues and comfort issues again, if I if you are tracking the body and it looks like my arm keeps breaking and bending in in in a backward direction, that is not comfortable, all right? It is torture of some kind right.

So, if your system is not working reliably, it is probably not worth doing or you have to assess is it really necessary. If it is then throw all the resources you have into it and make it work, but it might not be even though. It might look cool might not be necessary, all right? So, that finishes the hardware part, I want to talk about the bird's eye view of the software are there any questions about hardware, again this is very high-level overview. I am going to go into more details of these things. In fact, I am covering the fundamentals. So, by giving these examples, you will be able to see more of why I am jumping into various fundamentals.