Audio for Virtual Reality
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Stereophony

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These methods that we had been talking about so far, the headphone-based methods, they are obviously well suitable for virtual reality goggles because the user has to wear hardware anyway so and it is easy to just add headphones to the hardware.

And this is actually done, for example by the, by Ocular Swift or other virtual reality goggles. If they come with headphones you can be fairly sure that they are performing binaural audio reproduction.

Wearing headphones is of course not very

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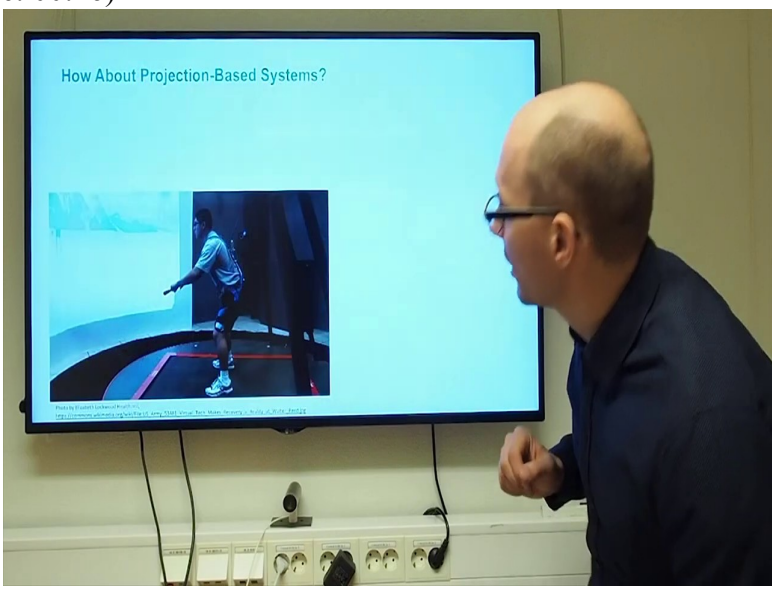

suitable for projection-based systems, that is systems that do not make the user wear goggles but, that, that provide the visuals on some projection screen and the user might still be required to wear some sort of glasses.

For example shutter glasses that, that synchronize out that, of that, you know that take care that the user see the right image at the right moment but still you would not want the user to wear headphones in this case.

First of all they are not very comfortable and also if there are several users inside such a system you would want them to communicate with each other without the isolation that might be provided with headphones. So here is an example of a projection based system.

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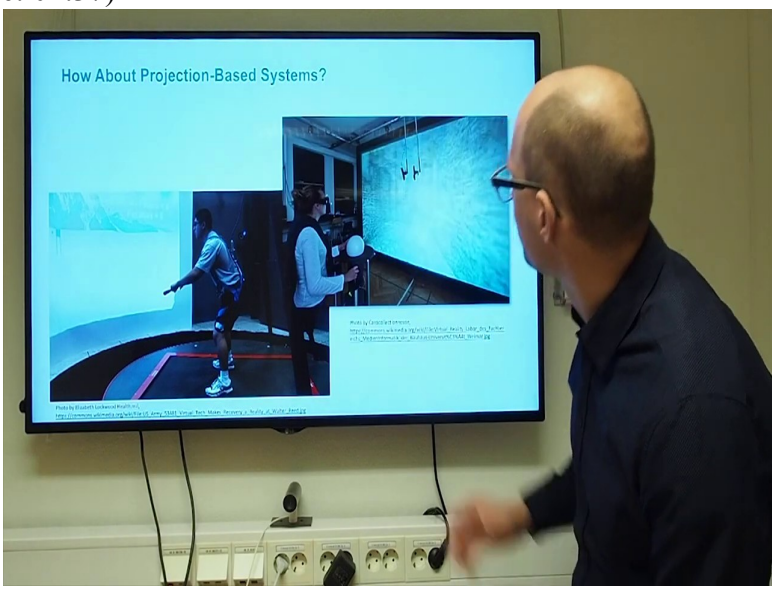

Here is another example. This one has only one screen but there are also projection-based system that have screens all around the user and even the floor and sometimes also the ceiling can be screen. So for those systems we would not want to use headphones.

We would like to install loudspeaker somewhere and make these, and use these loudspeakers to reproduce the audio.

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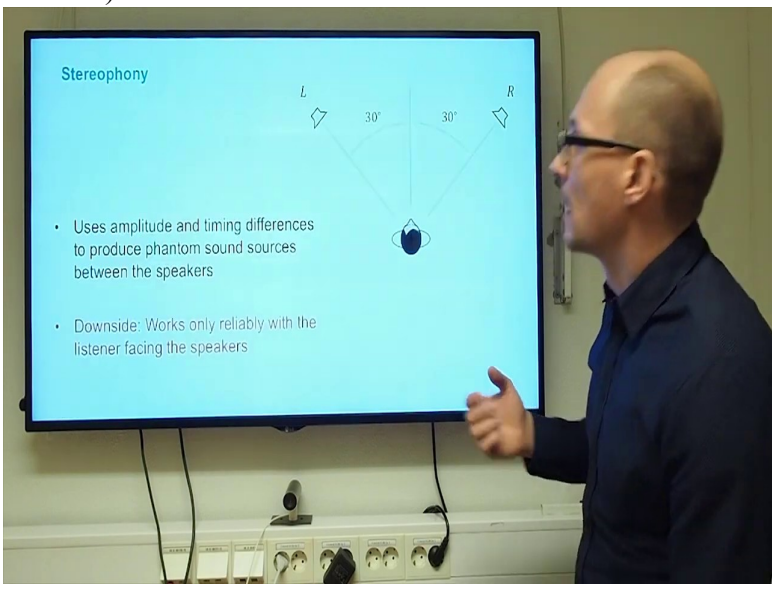

The straightforward method for this would be stereophony in which, which uses two loudspeakers and it assumes that the user is located at the symmetric plane between the loudspeakers, the angles that are indicated here, they are not that strict requirements.

There is a certain range of angles that works well and it happens so if you play, if you make both loudspeakers play the same signal. The user that is located and oriented like indicated on this plot will then hear a sound source in the middle, between the two loudspeakers.

It is actually not so straightforward to explain why we hear only one sound source although there are two physical sources and the location of that sound source that we are hearing does not even coincide with any of the physical sources.

Because of this kind of mystery, one terms the sound source that we are hearing, in this case if it is in the center, it would be in the center, one terms this sound source as phantom source to indicate that there is a more complicated situation going on.

If you would like to render or make the user perceive a sound source that is not strictly at the center between the two loudspeakers you change the relative amplitudes of the signals that you play through the loudspeakers or you change the timing.

So for example, if you keep the timing synchronized, so both loudspeakers play at the same time and you increase, say the level of the left loudspeaker then the higher the level would be, the more will the user localize the sound source towards the left loudspeaker.

So you can, any angle is possible and similarly if the right loudspeaker plays louder then the user will hear the sound source further to the right.

If both loudspeakers radiate any constant amplitude but if we delay the signal of one loudspeaker, so say I would be delaying the signal of the right loudspeaker slightly then the user will also hear the phantom source, will localize the phantom source closer to the leading loudspeaker.

And the timing differences that are being applied are of the order of 1 millisecond or smaller. One speaks of; one also speaks of the amplitude or delay panning in this case.

But of course the downside is that it works only reliably with the listener facing the two loudspeakers so if you allow the user to move freely, it does not work as well. If the user rotates or moves away from the symmetric plane.

And another downside is also that you can only render the phantom source angles between the two loudspeakers. So you cannot render anything on the side.

But of course if you have more loudspeakers and then you pair wise panning but as I mentioned orientation of the listener is very important. So if you do panning between two loudspeakers that are lateral to the user it will not work as reliably.