

CSE 190: Virtual Reality Technologies

LECTURE #10: SPATIAL AUDIO

Agenda

App presentations:

- Vishal
- Ray: Until You Fall

Technology presentations:

- Calvin
- Aditya
- Ray: Locomotion in VR

Agenda

Reading: Ambisonics

- What differentiates traditional surround sound techniques, such as Dolby surround, from Ambisonics audio?
- Why is Ambisonics audio particularly useful for VR environments?

Quest returns: Put in your locker by June 13th, email me once returned.

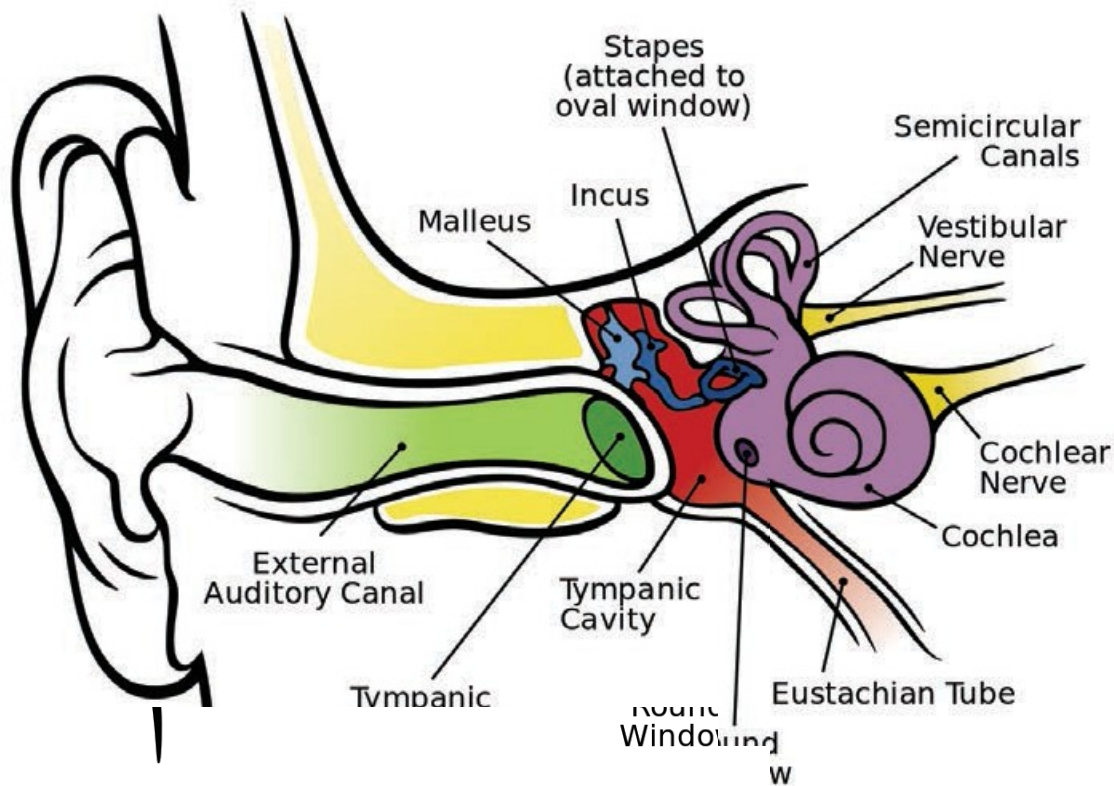
Final Project: due June 10 (next Friday)

Today's topic: 3D Audio

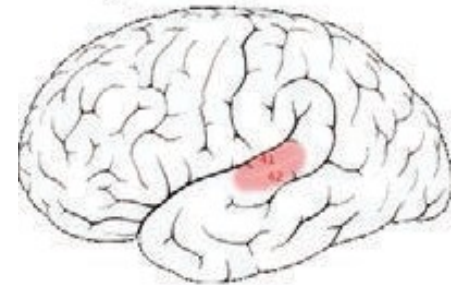
- Based on slides created by Prof. Wetzstein for EE 267 at Stanford

Spatial Audio

The Human Auditory System

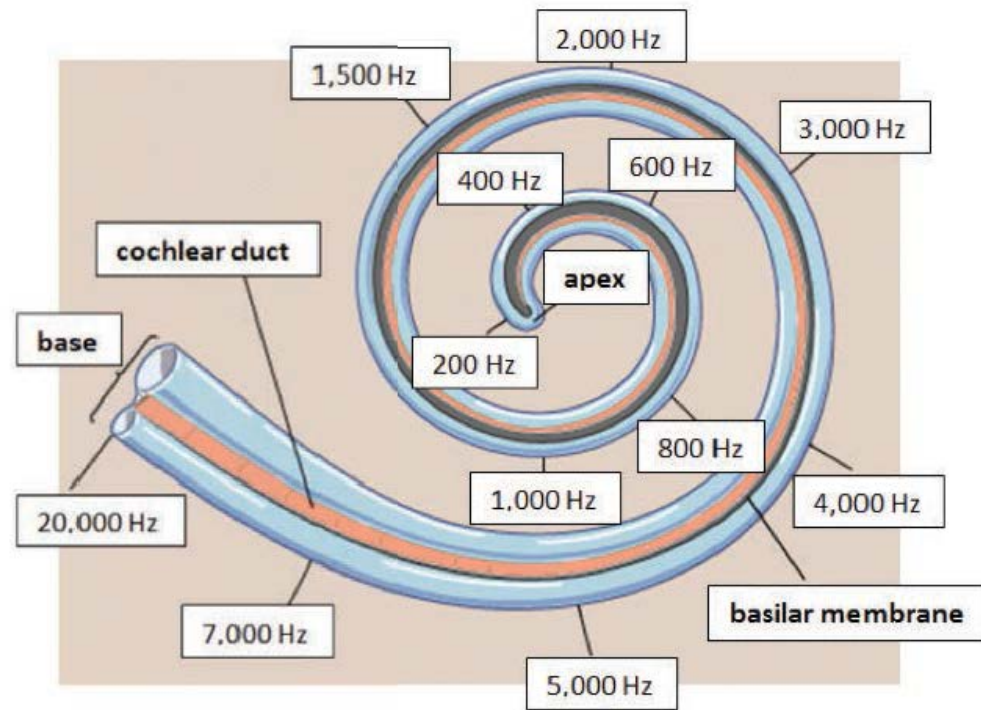


Primary auditory cortex



Source: wikipedia

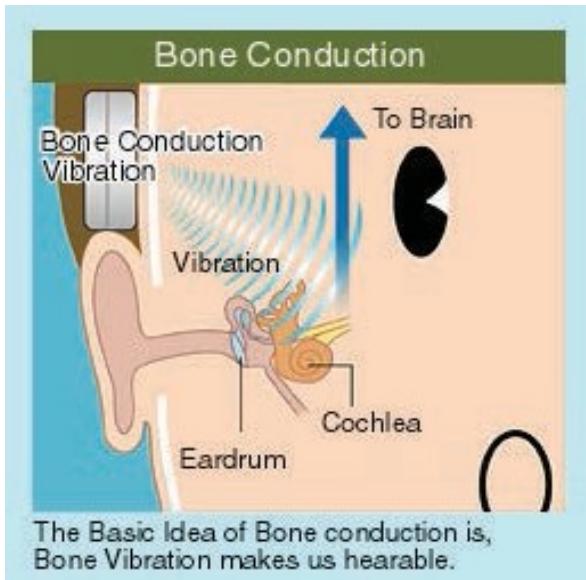
Hair receptor cells pick up vibrations



Wikipedia: cochlea

Bone Conduction

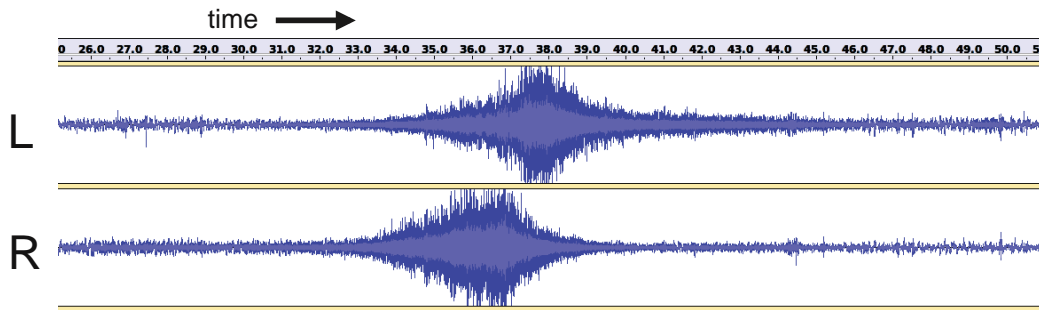
Bone conduction stimulates the eardrum mechanically to create the illusion of audio



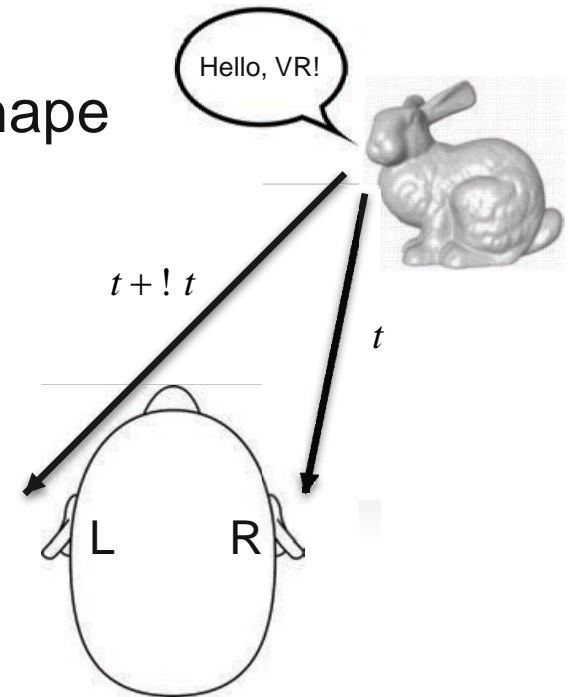
<http://www.goldendance.co.jp/English/boneconduct/01.html>

Stereophonic Sound

- mainly captures differences between the ears:
 - interaural time difference
 - amplitude differences from body shape (nose, head, neck, shoulders, ...)

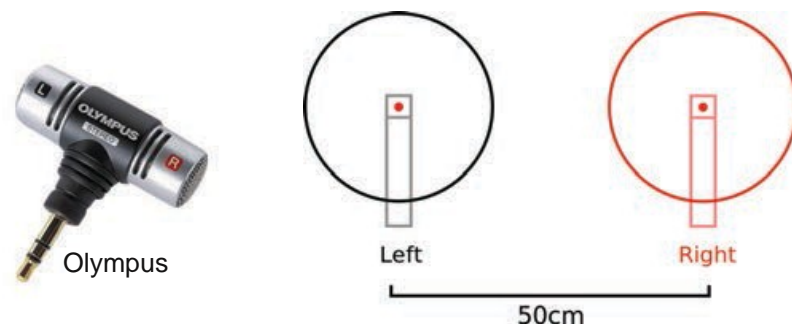


wikipedia



Stereophonic Sound Recording

- Uses two microphones
- A-B technique captures differences in time-of-arrival

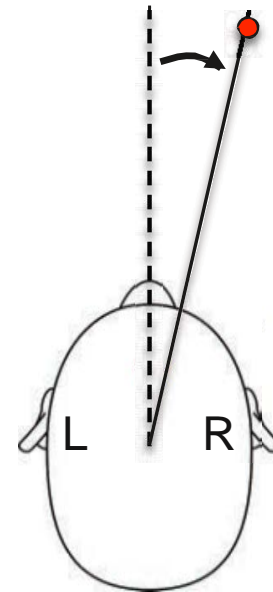


- Other configurations work too, capture differences in amplitude



Head-related Impulse Response (HRIR)

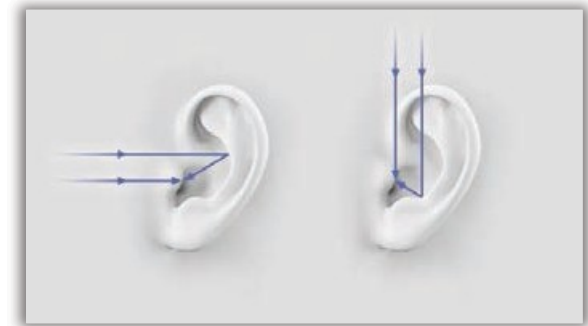
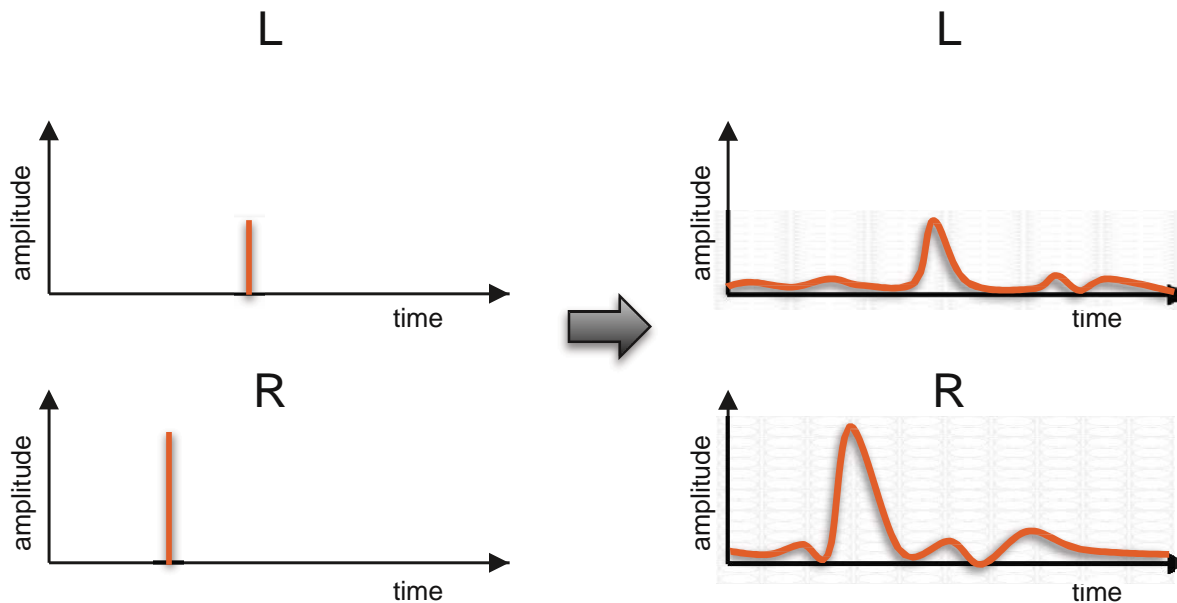
- Models phase and amplitude differences for all possible sound directions parameterized by azimuth and elevation
- Can be measured with two microphones in ears of mannequin & speakers all around



Zhong and Xie, "Head-Related Transfer Functions and Virtual Auditory Display"

Head-related Impulse Response (HRIR)

Measuring the HRIR is complicated:
includes scattering in ear, shoulders etc.



Surround Sound

Approximates a continuous wave field with a discrete set of speakers

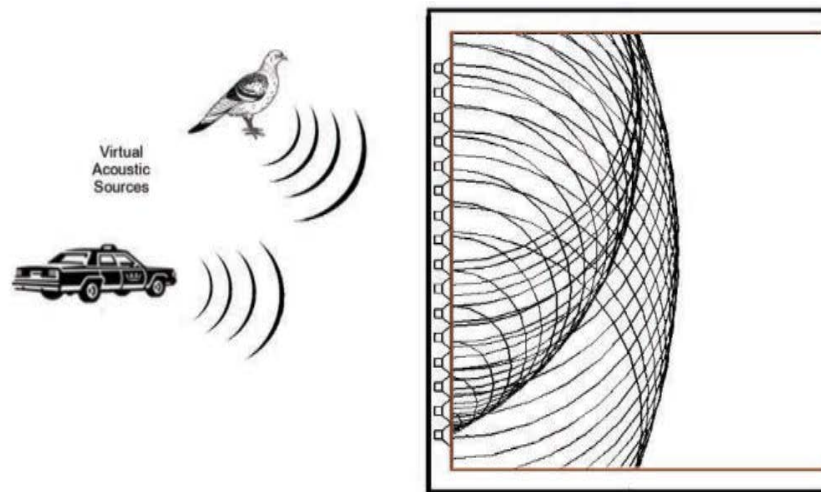


Most common:

5.1 surround sound =
5 (channels) + 1 (bass)

Surround Sound

- Approximates continuous wave field with discrete set of speakers
- Can also use more speakers for “wave field synthesis” (i.e., audio hologram) with phases of speakers synchronized



Surround Sound & HRTF

- For all speaker-based (surround) sound, we don't need an HRTF because the ears of the listener will apply them
- Speaker setup usually needs to be calibrated

Spatial Audio for VR

- VR/AR requires us to re-think audio, especially spatial audio!
- Could use 5.1 surround sound and set up “virtual speakers” in the virtual environment
 - Can use existing content, but hard to capture new content
 - Doesn't capture directionality from above/below

Spatial Audio for VR

Two primary approaches:

1. Real-time sound engine

- Render 3D sound sources via HRTF in real-time
- Used for games and synthetic virtual environments
- Many libraries available: FMOD, OpenAL, ...

Spatial Audio for VR

2. Spatial sound recorded from real environments
 - Most widely used format now: Ambisonics
 - Simple microphones exist
 - Relatively simple mathematical model
 - Only 4 channels needed for starters
 - Used in YouTube VR and many other platforms

Ambisonics

- Idea: represent sound incident at a point (i.e., the listener) with some directional information
- Full-sphere surround sound
- Easy to convert a point sound source to the 4-channel Ambisonics representation

Ambisonics – Spherical Harmonics

- Can record 4-channel ambisonics via special microphone
- Format supported by YouTube VR and other platforms



<http://www.oktava-shop.com/>

References

- Google's take on spatial audio: <https://developers.google.com/vr/concepts/spatial-audio>

HRTF:

- Algazi, Duda, Thompson, Avendado "The CIPIC HRTF Database", Proc. 2001 IEEE Workshop on Applications of Signal Processing to Audio and Electroacoustics
- Download CIPIC HRTF database here: <http://interface.cipic.ucdavis.edu/sound/hrtf.html>

Resources by Google:

- <https://github.com/GoogleChrome/omnitone>
- <https://developers.google.com/vr/concepts/spatial-audio>
- <https://opensource.googleblog.com/2016/07/omnitone-spatial-audio-on-web.html>
- <http://googlechrome.github.io/omnitone/#home>
- <https://github.com/google/spatial-media/>