CS-525H: Immersive HCI

Augmented Reality

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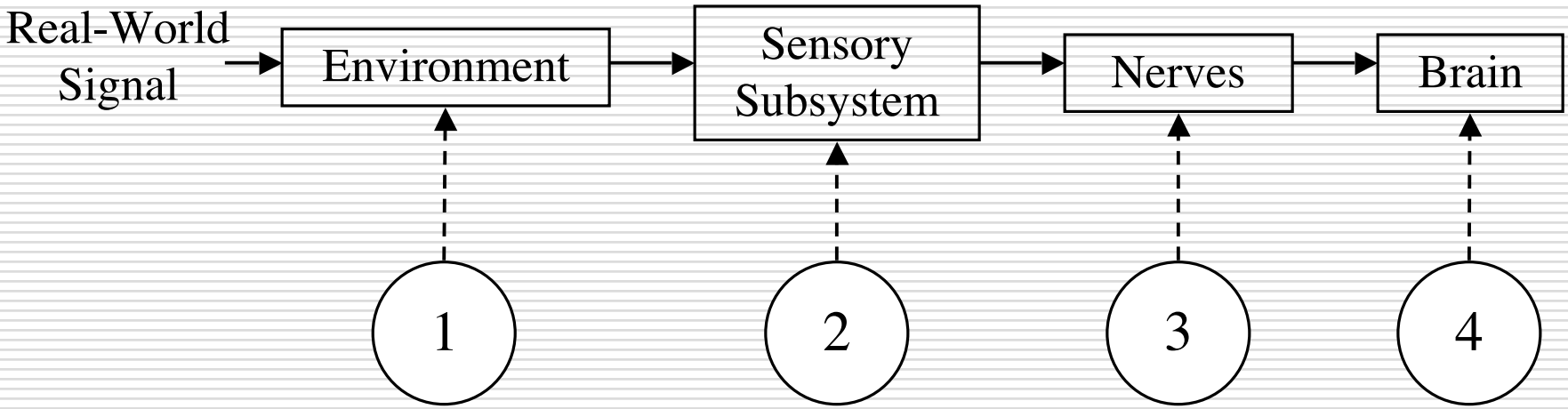
Motivation

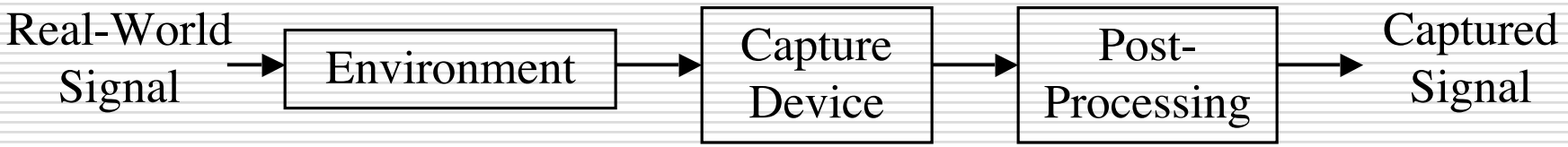
- Augmented Reality
  - Mixing of real-world (RW) and computer-generated (CG) stimuli
  - Graphical overlays on the real world
  - Adding information to real experiences
- Much work on visual sense
- Can be extended to auditory sense
  - Other senses?
- For the user to merge RW and CG, attributes must be matched
  - Visual: Lighting & shadows, level of fidelity
  - Audio: CG and RW sound occlusion and reflection

Real-World Stimulus Paths

- Direct

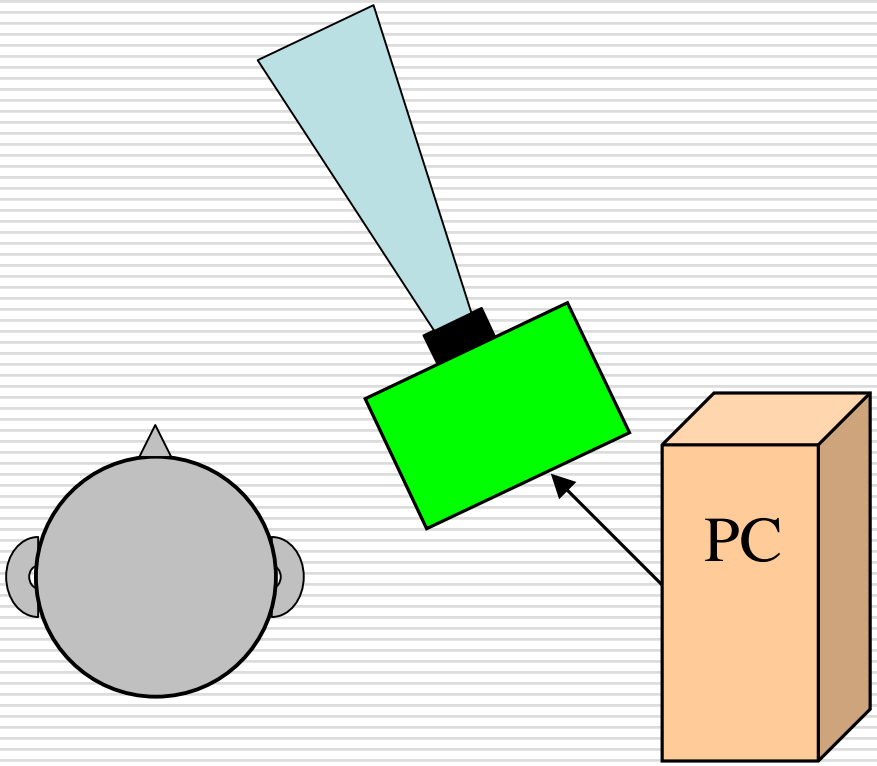


- Captured/Mediated



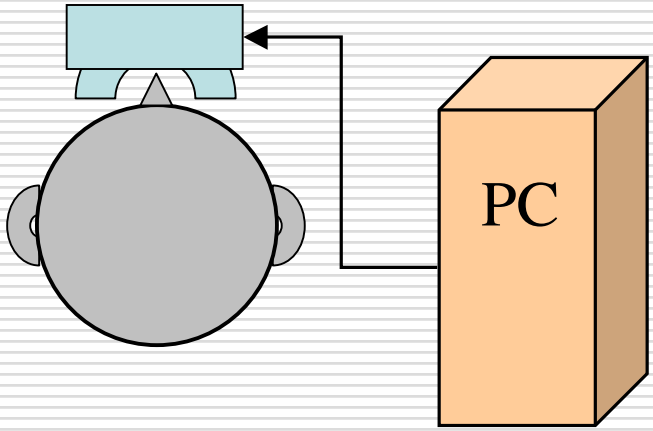
Visual Sense

- Projection
  - Mixing in the environment (far)



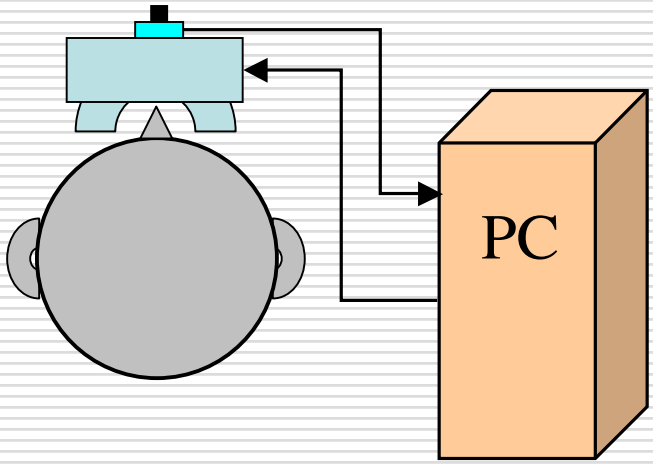
Visual Sense (cont.)

- Optical-see-through AR
  - Mixing in the environment (near)



Visual Sense (cont.)

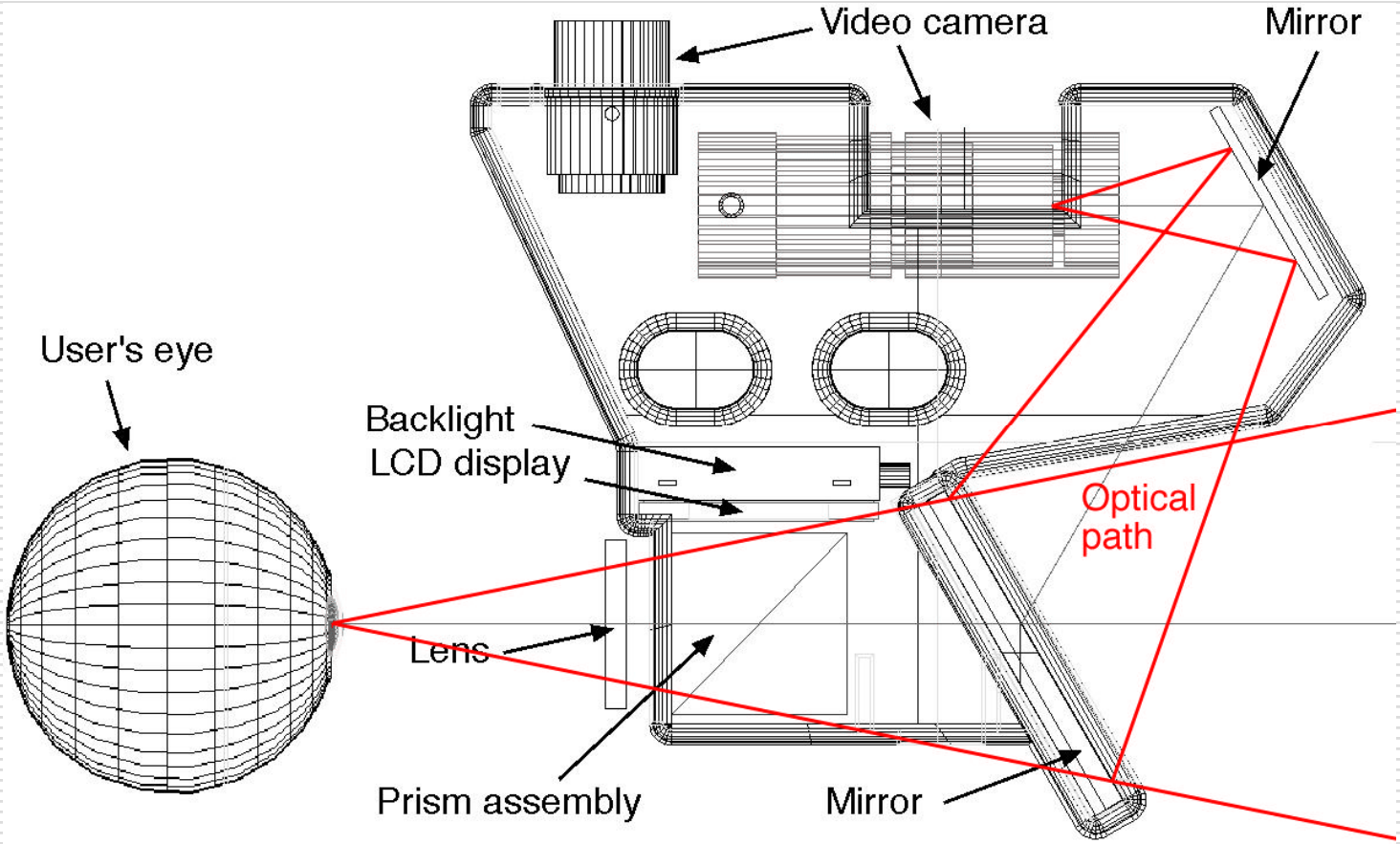
- Video-see-through AR
  - Mixing in the Computer



Video-See-Through HMD

(Image: Fuchs, et al., Medical Image Computing and Computer-Assisted Intervention (MICCAI) '98, LNCS, 1998, Vol. 1496/1998, 934)

Video-See-Through HMD (cont.)



(Image: Fuchs, et al., Medical Image Computing and Computer-Assisted Intervention (MICCAI) '98, LNCS, 1998, Vol. 1496/1998, 934)

Video-See-Through HMD (cont.)

- NVIS: nVisor MH60-V (2010)

http://www.nvisinc.com/product2009.php?id=57

Using Visual AR: SDKs

- ARToolKit
  - http://www.hitl.washington.edu/artoolkit/
  - Earliest usable kit
  - Now Open Source (free)
  - Commercial versions for iPhone & Android
    - http://www.artoolworks.com/
- Studierstube ES & Tracker
  - http://studierstube.icg.tu-graz.ac.at/handheld_ar/
  - *ES* sits on top of *Tracker*
  - Not free

Using Visual AR: SDKs Examples

- ARToolKit
  - http://www.youtube.com/watch?v=5M-oAmBDcZk
  - (local clip)
- Studierstube ES
  - http://www.youtube.com/watch?v=JwluCuVKO9c
  - (local clips)

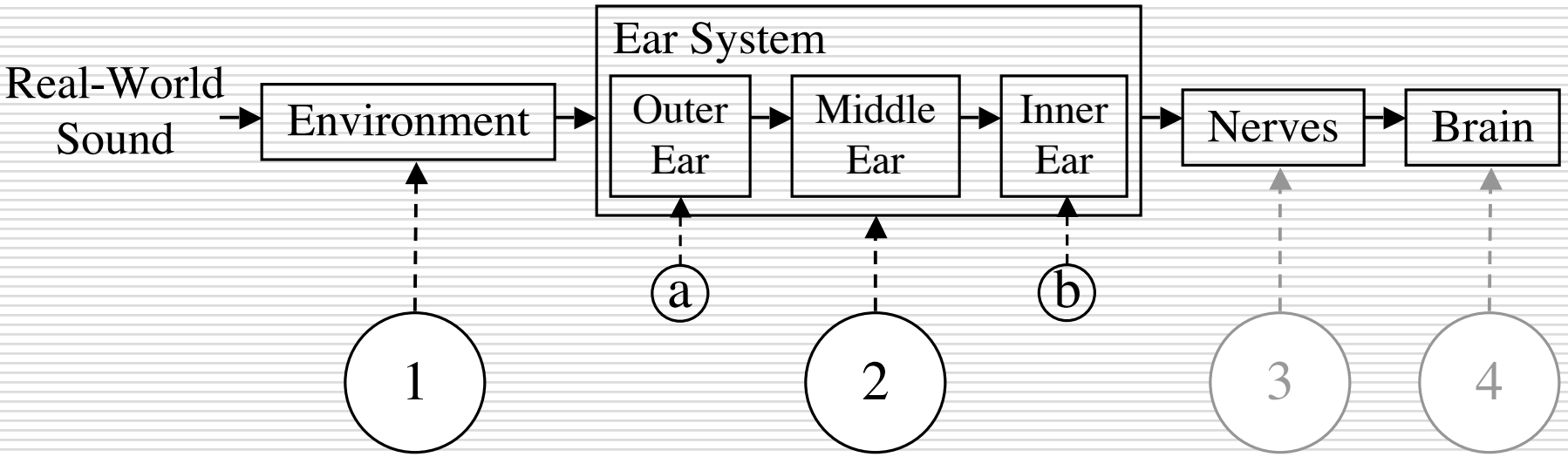
Using Visual AR: Tools

- Google SketchUp + ARMedia Plugin
  - http://www.youtube.com/watch?v=wsQ-YGgVUT0
  - (local clip)
  - (live demo)
  - http://sketchup.google.com/
- Layar for mobile devices
  - http://www.layar.com/
  - Layering tool for layar browser
    - "Like HTML for AR"
  - (local clip)

Using Visual AR: Tools (cont.)

- Cereal?
  - http://www.youtube.com/watch?v=jGdSslAJRwM
  - (local clip)
- Slot Cars?
  - http://www.youtube.com/watch?v=WMWEYqYPDfc
  - (local clip)
- Magic Tricks?
  - http://www.youtube.com/watch?v=Mk1xjbA-ISE
  - (local clip)
- Heads-up Display in Cars (play GE clip)
- Mobile AR (play Nokia clip)
- Mobile 3rd Party
  - http://news.bbc.co.uk/2/hi/technology/8193951.stm

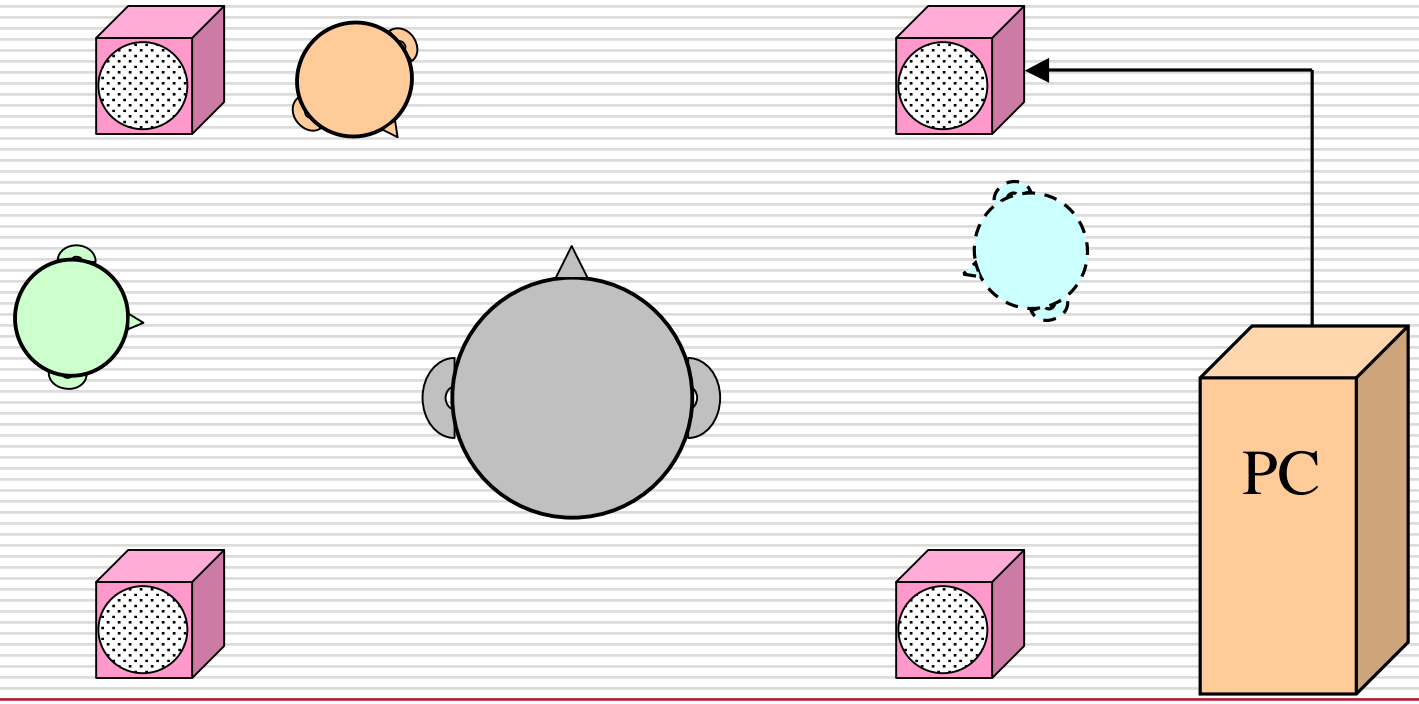
Sound Paths & Mixing Points



- Typical VR/AR systems use speakers (1) or headphones (2a)
- Our approach performs the mixing at the cochlea (2b)

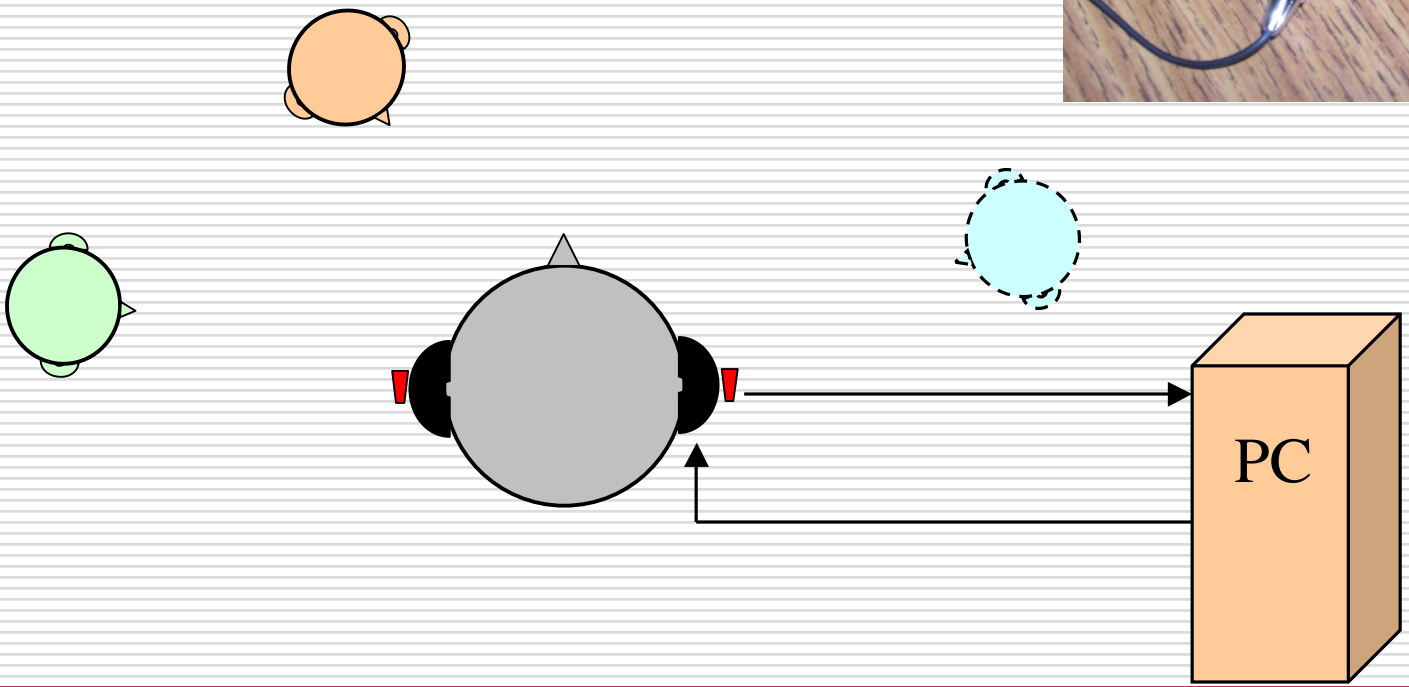
Auditory Sense

- Acoustic-Hear-Through AR (Speakers)
  - Mixing in the environment (far)



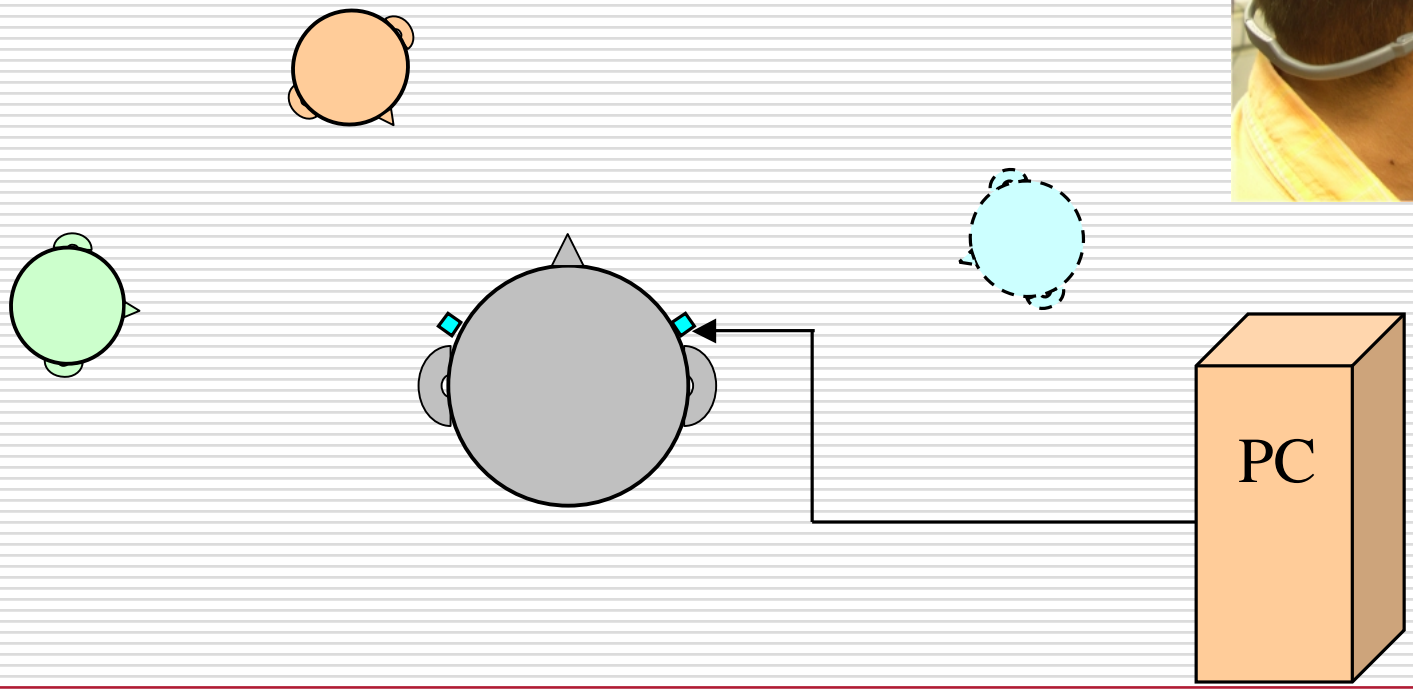
Auditory Sense (cont.)

- Mic-Through AR
  - Mixing in the computer



Auditory Sense (cont.)

- Hear-Through AR
  - Bone conduction
  - Mixing at the sensory subsystem



Bone-Conduction Example

- The sound of your own voice is a combination of:
  - Sound reaching your ears through the air
  - Vibrations reaching your cochlea though your head
- Example
- Sound heard through the air
- Sound heard through the head
- Combined sound

Mauldin & Scordilis, 2004

Research Questions

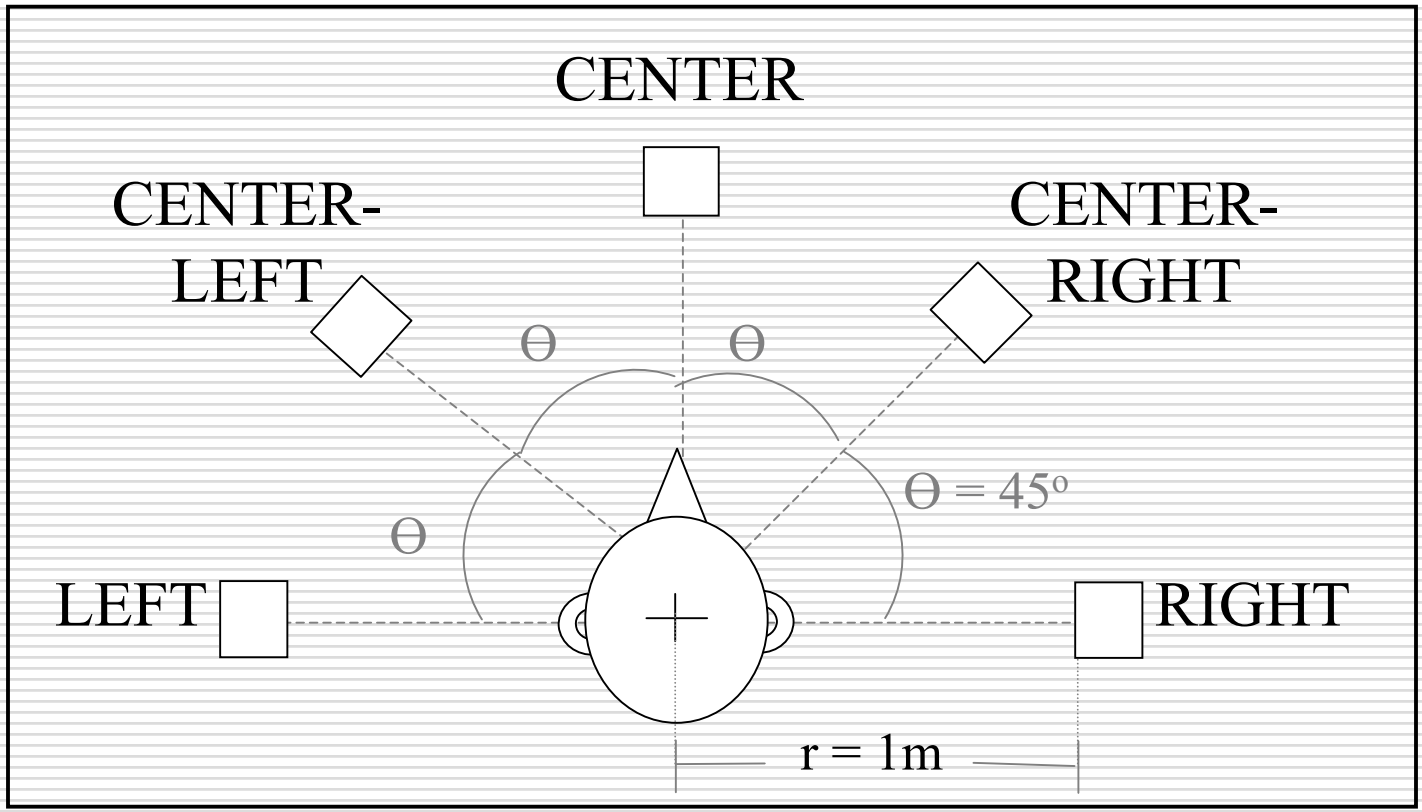
- How well can people localize sound using bone conduction?
- What types of sound works best?
  - Ambient sound
  - Spoken voice
  - Sound FX
  - Music
- We looked at basic sounds (sine waves) of various frequencies
  - Stationary and moving sounds

Design of the User Study

- 24 Computer science students (22 male)
- 3 Main treatments (Audio Devices)
  - Speakers, Headphones, Bone-Conduction Device
- Each subject performed 63 trials with each device
  - 3 Frequencies
    - Low (200Hz), Medium (500Hz), High (1kHz)
  - 7 sound samples (5 sound locations + 2 directions)
    - Left, Center-Left, Center, Center-Right, Right
    - Moving, right-to-left moving
  - 3 repetitions of each combination
  - 3 * 7 * 3 = 63

User Study

- Physical/Virtual sound locations



User Study (cont.)

- Each sample was played for 1 second
- Subjects wore a blindfold
- No HRTFs used
- Subjects had to identify location/direction

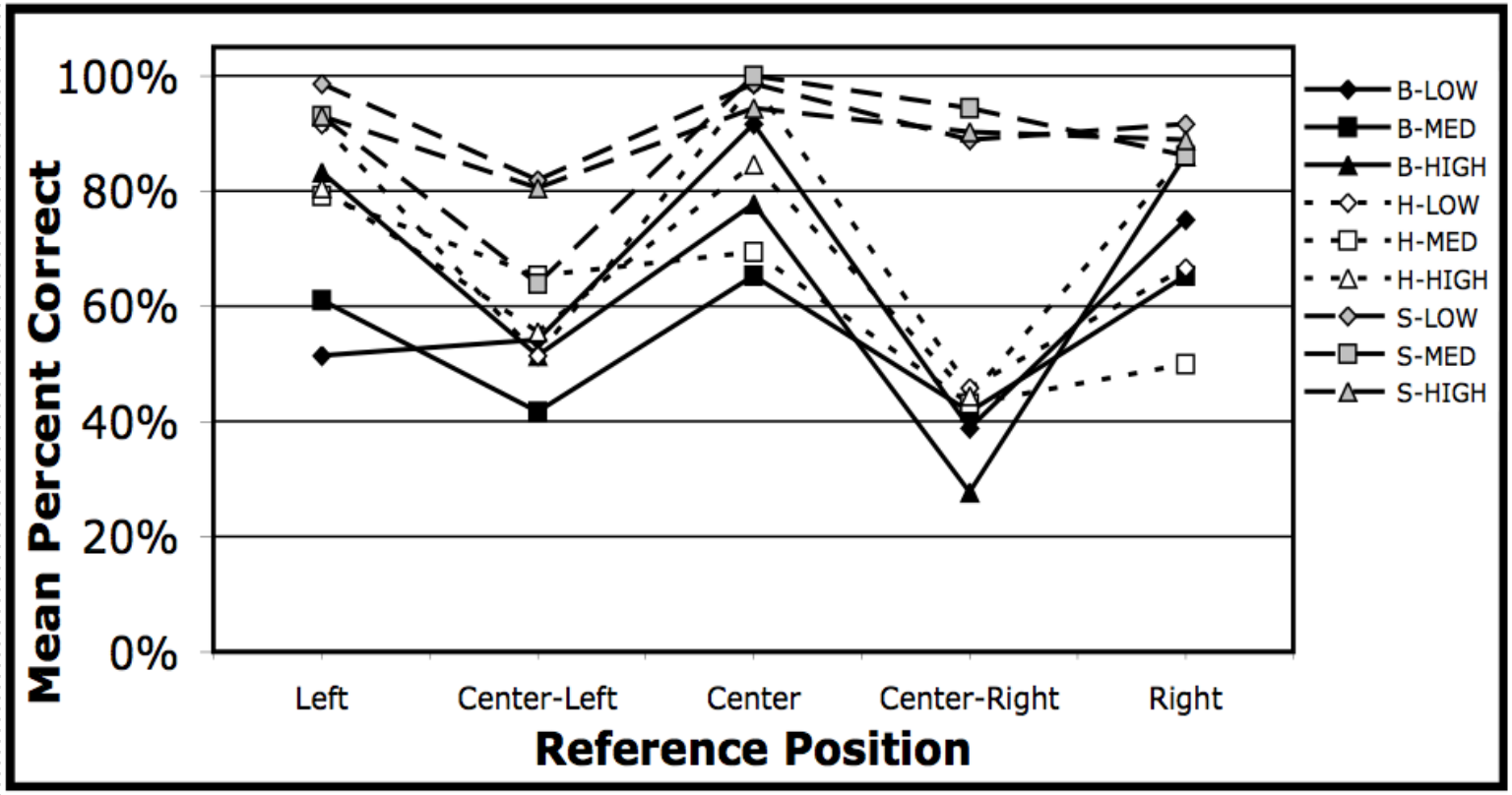
Results

- Accuracy for **Stationary** Sounds
  - Speakers > headphones > bone conduction
  - High-Freq. == Low Freq., both > Medium Freq.
- Accuracy for **Moving** Sounds
  - Speakers == Bone conduction
  - Bone Conduction == Headphones
  - Speakers > headphones (α = .05)

	Stationary	Moving
Audio Device	S H B	S B H
Frequency	HIGH LOW MED	*ns*
Interaction	*ns*	*ns*

Results (cont.)

- Problems with the "in-between" locations
  - Center-Left/Center-Right



Analysis

- Real-world sound
  - High fidelity
  - Low control
- Computer-generated sound
  - Low(er) fidelity
  - Complete control
- Later mixing point = Closer to the brain
  - More personalized, but
  - More processing for transforming and mixing

Analysis (cont.)

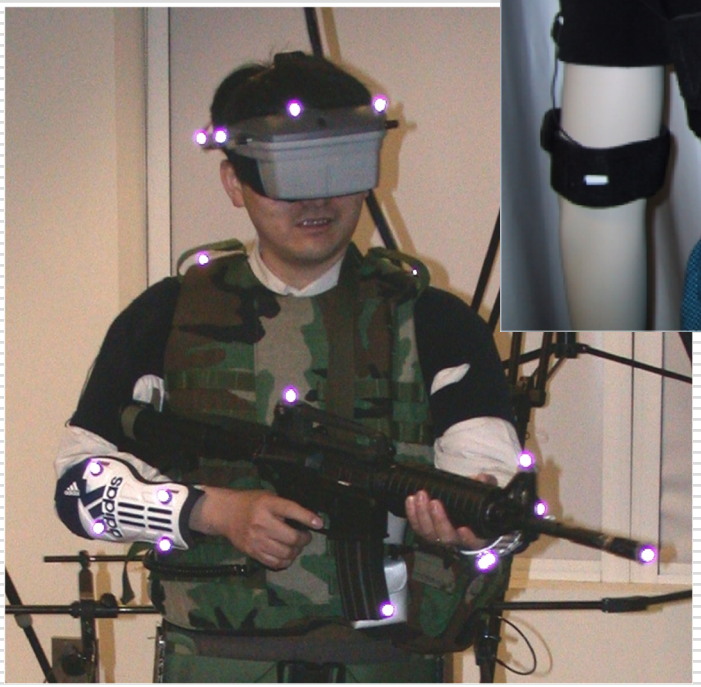
- Bone-conduction/headphone approaches
  - Require head tracking for CG sound
  - Require processing for spatialization (e.g., HRTF or BRTF)
- Speaker-based
  - Allows for shared experience (like projection systems in visual field)

Haptic Sense

Mixing in Computer (teleoperation) or in Environment
(Immersion CyberGrasp)

Mixing at Sensory Subsystem
(Novint Falcon)

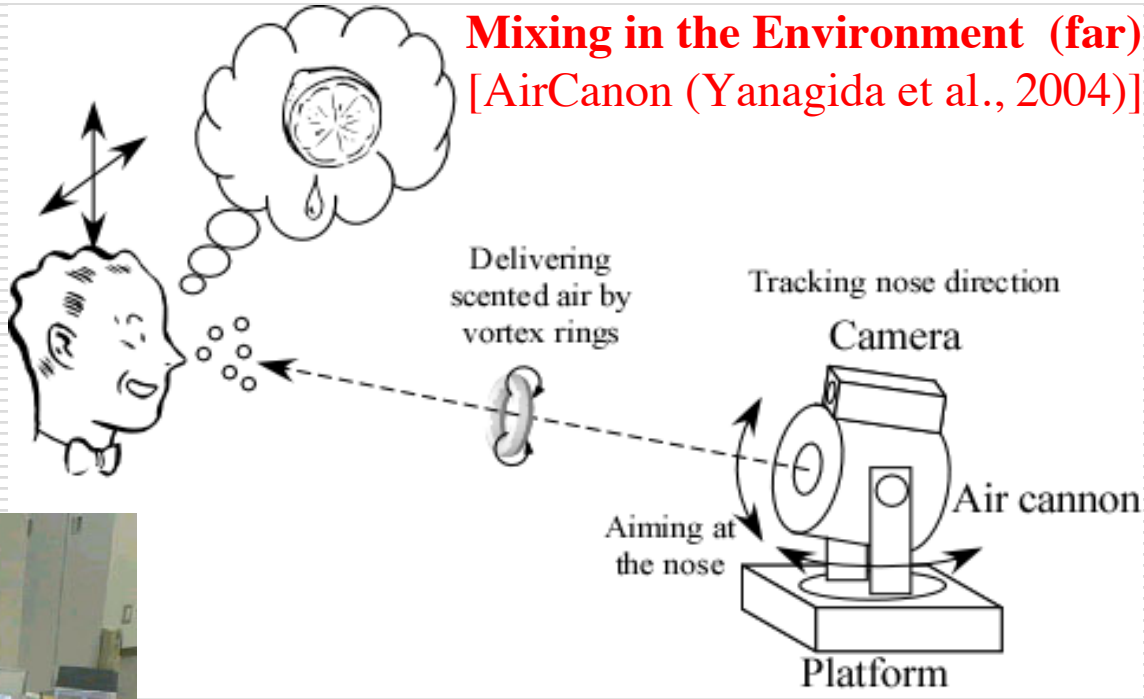
Haptic Sense (cont.)



Mixing in the Environment (Lindeman, VRST 2004)

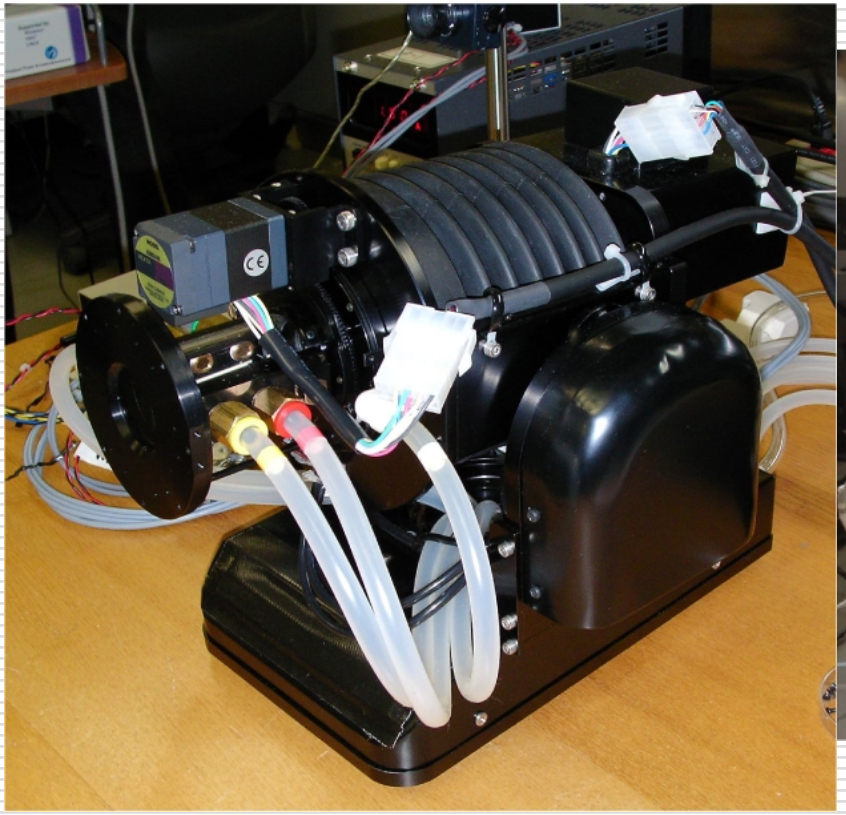
Olfactory Sense

Mixing in the Environment (far)
[AirCanon (Yanagida et al., 2004)]

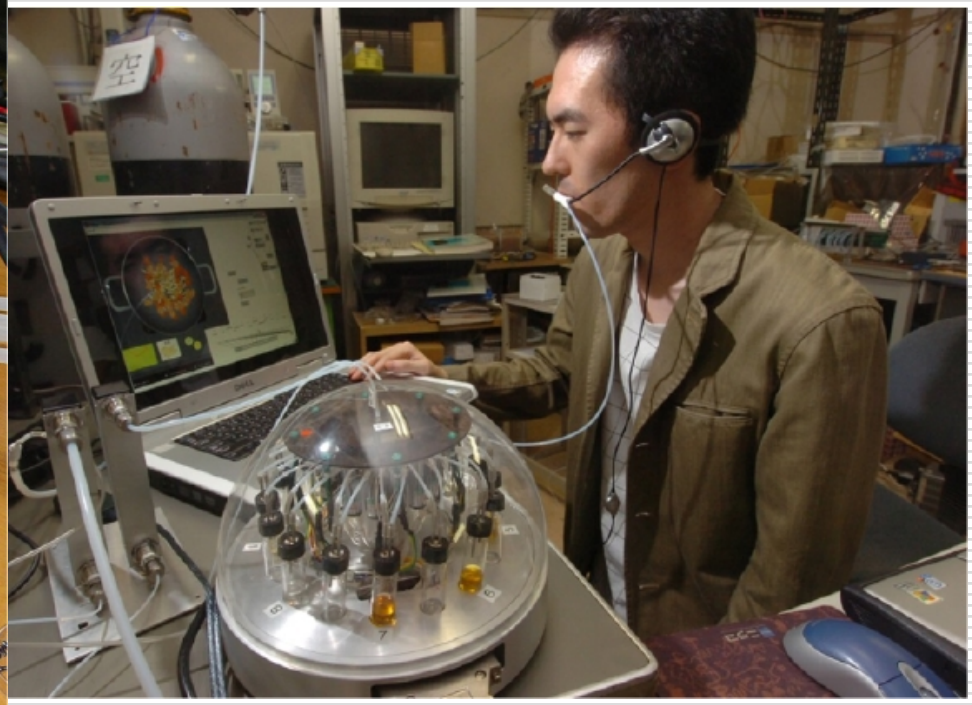


Mixing in the Computer
(Hirose et al. 1997)

Olfactory Sense (cont.)



Mixing in the Environment (mid)
[AirCanon (Yanagida et al., 2004)]



Mixing in the Environment (near)
(Nakamoto & Min, 2007)

Gustatory Sense

- Bite interface
  - Really haptics (near)

Iwata, 2004
(photos: Sid Fels)

Gustatory Sense (cont.)

- Edible bits
- Straw-like interface
  - Mixing in the env.

(Nakamoto, 2007)

(Maynes-Aminzade, 2005)

Gustatory Sense (cont.)

Final Thoughts

- What about a 3D printer+robot arm?
- RW stimuli
  - High fidelity / low control
- CG stimuli
  - Low(er) fidelity / complete control
- Later mixing point = more "personal" stimuli
  - Closer to the brain
- Multi-sensory approaches are interesting
  - Compensate for weaknesses in one sense with another sense
  - Use speakers for environmental, bone-conduction for virtual characters