Non-visual AR

Vorlesung „Augmented Reality“
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Non-visual AR

- Acoustic augmentation
  - Navigation for the blind
  - Car parking Aids
  - Acoustic Ambient UIs
- Tactile augmentation
  - Tactile pen interfaces
  - Wearable tactile devices
  - Tactile augmentation in cars
- Olfactory augmentation

Definition von AR nach Azuma

Drei Kriterien eines AR-Systems:
1. Kombination von realen und virtuellen Inhalten
2. Interaktiv in Echtzeit
3. Im 3D-Raum registriert

→ Passt nicht so recht für NVAR !!!

Acoustic augmentation

Navigation for the blind
Acoustic Ambient UIs
Car parking Aids

Some philosophical questions...

- Is a Walkman or iPod a form of acoustic AR ??
- Is a vibration alarm a form of tactile AR ??
- Is a deodorant a form of olfactory AR ??

Spatial hearing

- Caused by:
  - Interaural time difference (ITD)
  - Interaural intensity difference (IID)
  - Head related transfer functions (HRTF)
- Better for high than for low frequencies
**Vector Based Amplitude Panning**

\[
p = g_1 \cdot p_1 + g_2 \cdot p_2 = Lg
\]
\[
g = p' \cdot L^2
\]

→ 3D spatialization with speakers in the environment

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**Drishti [Helal et al. ISWC 2001]**

- ...basically the same as PGS

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**Head Related Transfer Functions**

- For all positions around the head, measure impulse response from the source to the ear drum \( \rightarrow \) HRTF
- Fourier transform is the HRTF
- It captures all physical cues for source localization
- HRTF is different for everybody
- Once you know the HRTF for the left ear and the right ear, you can synthesize accurate binaural signals from a monaural source

→ 3D spatialization with headphones

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**UCSB Personal Guidance System (PGS)**

[Loomis et al. 1985 – now]

- Pedestrian navigation system for the blind
- Use GPS for tracking
- Issue voice commands over headphones
- Controlled by voice input
- Currently the size of a small shoulder bag

- Video1 Video2

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**Swan [Walker 2003]**

- Same story again, but:
  - Non-speech auditory interface
  - Navigation Beacon sounds guide the listener along a predetermined path, from a start point, through several waypoints, and arriving at the listener’s destination.
  - Object Sounds indicate the location and type of objects around the listener, such as furniture, fountains, doorways, etc.
  - Surface Transition sounds signify a change in the walking surface, such as sidewalk to grass, carpet to tile, level corridor to descending stairway, curb cuts, etc.
  - Locations, such as offices, classrooms, shops, buildings, bus stops, are also indicated with sounds.
  - Annotations are brief speech messages recorded by users that provide additional details about the environment. For example, “Deep puddle here when it rains.”

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**LMU time-multiplexed display**

- Turning arrow, visible for all
- Beeping sound in the headphone of an MP3 player
- Beeps when arrow points in the right direction

- Common object, individual augmentation
Car parking aids

- Sensors in the bumper
  - Detect distance to next car
  - At speeds below 10km/h
- Car Audio system:
  - Plays a beeping sound
  - Frequency corresponds to distance
  - Uses front/back/left/right speakers
  - Direction corresponds to direction ;-) 

Virtual Acoustic Enhancement of TCAS

- TCAS = Traffic Collision Avoidance system
  - Standard in all airplanes > 30 seats
  - Detects potentially colliding planes with TCAS
  - Can resolve the problem by changing altitude
- Normally only on a central display
- Here: spatialize sound so that it comes from the direction of the threat/intruder

Audio Aura [Mynatt et al. CHI 98]

- Portable wireless headphones
- Users tracked via active badges
- Localized audio cues provided:
  - Message at the door of a person’s office, if the person is absent
  - Notification of incoming emails
  - New books in a shelf

<table>
<thead>
<tr>
<th>Sound Effect</th>
<th>Mode</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nothing new</td>
<td>a single gail-ry</td>
<td>You have no news</td>
</tr>
<tr>
<td>A little (&lt; 5 sec)</td>
<td>a gull calling a few times</td>
<td>You have a new message</td>
</tr>
<tr>
<td>Silence (5 - 15 sec)</td>
<td>a few gulls calling</td>
<td>You have a new message</td>
</tr>
<tr>
<td>A lot (more than 15 sec)</td>
<td>gulls squabbling, tossing a mackerel</td>
<td>You have a new message</td>
</tr>
</tbody>
</table>

FhG FIT Project Listen!

- Exhibition in „Kunstmuseum Bonn“
- Visitors wear tracked headphones
- Different areas contain different sounds
- Sound follows rules
  - Changes with motion speed
  - Fades after time
  - …
  - → acoustic landscape

SoundScapes [Mauney & Walker, 2004]

- Idea: play natural sounds (water, weather, animals) in the background
  - Can fade into the subconscious
  - Can be listened to and then conveys a meaning
  - Sonify continuous data such as the stock market index
- Map different sounds to different meanings
- Audio Example

SoundScapes [Walker, 2004]

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Type</th>
<th>Sound Generated</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.50%</td>
<td>Loop</td>
<td>River at normal gain, speed, and tempo</td>
</tr>
<tr>
<td></td>
<td>Loop</td>
<td>Light rain booms</td>
</tr>
<tr>
<td></td>
<td>Loop</td>
<td>Heavy rain (multiple overlapping samples, increased gain)</td>
</tr>
<tr>
<td></td>
<td>Random Hit</td>
<td>Thunder crashes at 1 sample per minute</td>
</tr>
<tr>
<td>&lt; 1.00%</td>
<td>Random Hit</td>
<td>More violent thunder at 1 sample per minute</td>
</tr>
</tbody>
</table>
Tactile augmentation

- Tactile pen interfaces
- Wearable tactile devices
- Tactile augmentation in cars

Haptic Pen: [Lee et al. UIST 2004]

- Solenoid mounted to the back of a pen
- Accel. along the axis
  - First down
  - Then up
- Creates the feeling of a clicking button

Cybergrasp force feedback glove

- Mechanical construction (exoskeleton) around hand
- Actuated from a control unit via cables
- Force feedback for each finger
  - Maximum Continuous Force: 12 N per finger
  - Force resolution: 12-bit
  - Weight: 350g
  - Workspace: 1 meter radius
  - Host Interface: RS-232 and Ethernet are supported

Ambient Touch [Poupyrev et al. 2002-2004]

- Mount touch screen glass on piezo devices
- Whole glass moves when actuated
- Movement is felt in the pen
  - Explore textures on the screen
  - Provide feedback when entering/leaving widgets
  - Works with regular pens and on small devices

Citroen Lane Departure Warning System

- Detects white lines by 6 IR reflection sensors under the car
- If white line is crossed without using the indicator (Blinker):
  - Triggers vibration on the respective side of the driver's seat
- Can detect white lines as well as the temporary road markings in yellow
### BMW iDrive

- **Central control wheel**
  - Turn + push
  - Navigation in menus
- **Force feedback** depending on menu structure
  - Clicks between entries
  - Stop at end of list
- **Tactile augmentation** of a control device

### Aromatic Output
- From: Joseph "Jofish" Kaye, Making scents: aromatic output for HCI, Interactions, Volume 10, Number 1 (2004), Pages 48-61
- Humans use their sense of smell
  - Is food safe to eat?
  - Is there danger due to a fire?
  - Relationships
- An almost entirely unexplored medium in HCI
  - There are reasons for this: technical difficulties in emitting scent on demand,
  - chemical difficulties in creating accurate and pleasant scents

### Olfactory augmentation
- Technology of olfactory displays
- Application ideas
- Current application

### Physiology and Chemistry of Smell
- A thousand different kinds of olfactory receptors in our nose, and it is thought that each can sense a single kind of chemical bond in a molecule
- No abstract classification
  - Examples: how does mint taste? It tastes like … mint
  - Compared to colors: green vs. spinach colored
- Rapidly acclimatized
  - Less than 1 minute
- Human Olfactory Bandwidth
  - … hard to tell
  - Perfumers and florist can distinguish many different smells - potentially thousands

### Technology
- Explored in movie theaters and VR… but not really successful
- Different technologies
  - www.scentury5d.com/
  - See for examples: http://www.aromajet.com/game.htm and J. Kaye, Making scents: aromatic output for HCI
Ideas in Smell Output, Open Questions

- Olfactory Icons
  - Smell a shot fired each time you press the trigger in Quake
- Ambient Notification
  - Smell of rose to notify you of a date

The question of what information should be displayed is fundamental. Olfactory display is useful for slowly-moving, medium-duration information or information for which an aggregate representation is slowly changing.


Citroen Parfumeur d'ambiance

- Scent cartridge to be inserted in air + AC vents
- Amount of scent can be regulated
- Last 2 months at 1hr/day
- 3 scents delivered with car

Summary

- Majority of AR is visual ;-)!
- Acoustic augmentation is the most widely used form of NVAR
- Tactile augmentation has interesting potential
- Olfactory augmentation is hard

Weekend is close