

Non-visual AR

Vorlesung „Augmented Reality“

Prof. Dr. Andreas Butz

WS 2006/07

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

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 ??



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 !!!

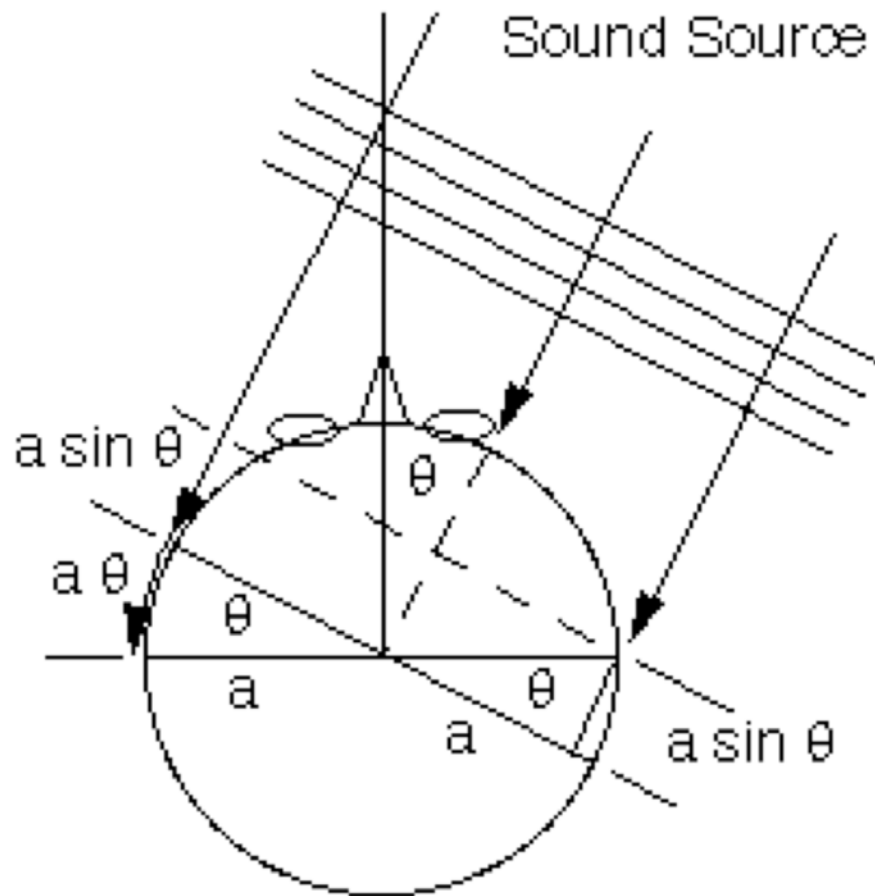
Acoustic augmentation

Navigation for the blind

Acoustic Ambient UIs

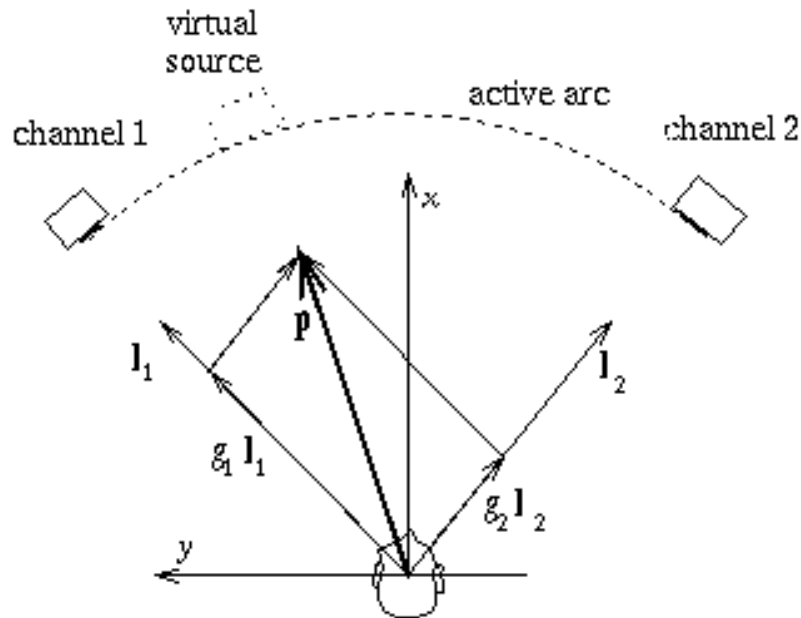
Car parking Aids

Spatial hearing



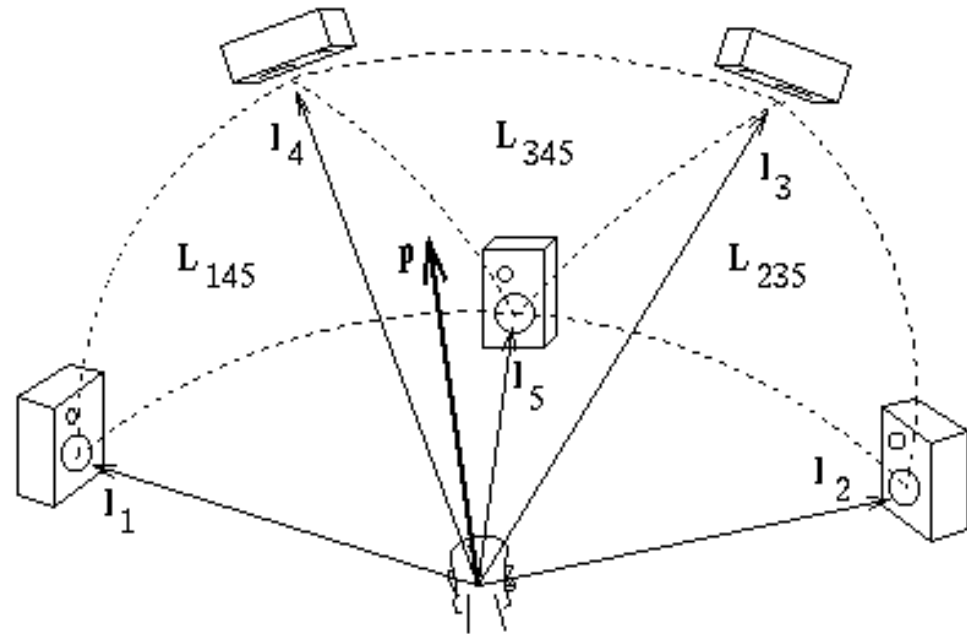
- Caused by:
 - Interaural time difference (ITD)
 - Interaural intensity difference (IID)
 - Head related transfer functions (HRTF)
- Better for high than for low frequencies

Vector Based Amplitude Panning



$$p = g_1 l_1 + g_2 l_2 = L \vec{g}$$

$$\vec{g} = L^{-1} p^T$$



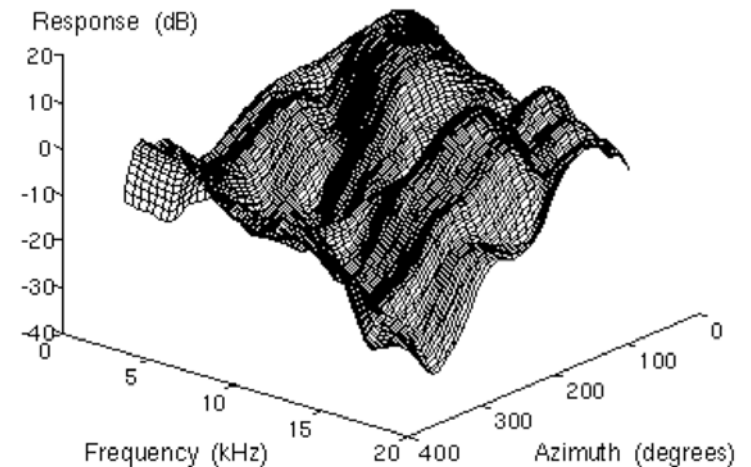
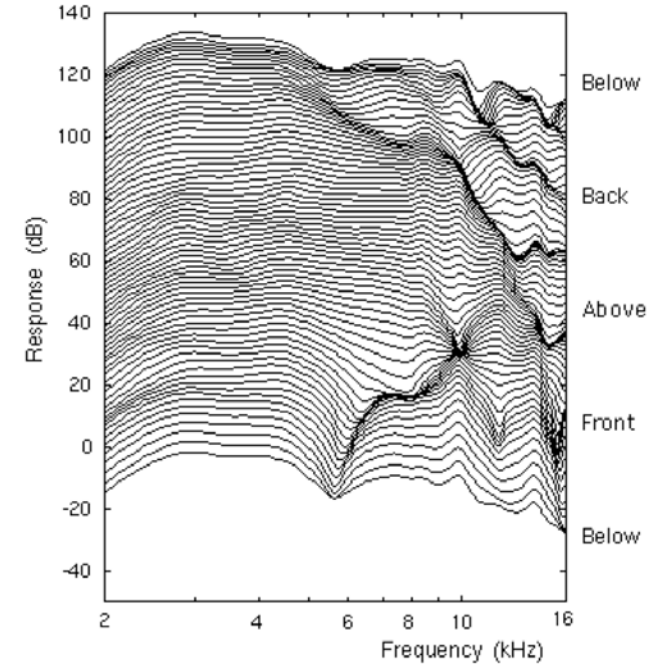
$$p = g_1 l_1 + g_2 l_2 + g_3 l_3 = L g$$

$$g = L^{-1} p^T$$

➔ 3D spatialization with speakers in the environment

Head Related Transfer Functions

- For all positions around the head, measure impulse response from the source to the ear drum → HRIR
- 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



UCSB Personal Guidance System (PGS)

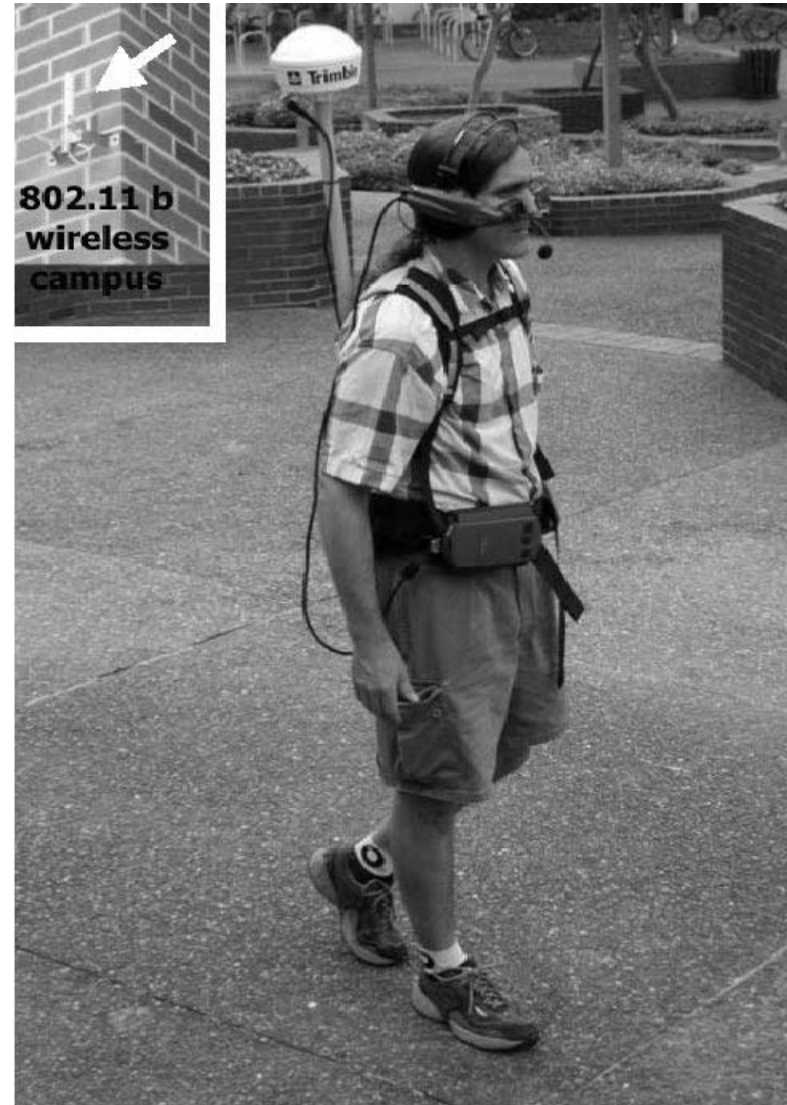
[\[Loomis et al. 1985 – now\]](#)

- 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](#)



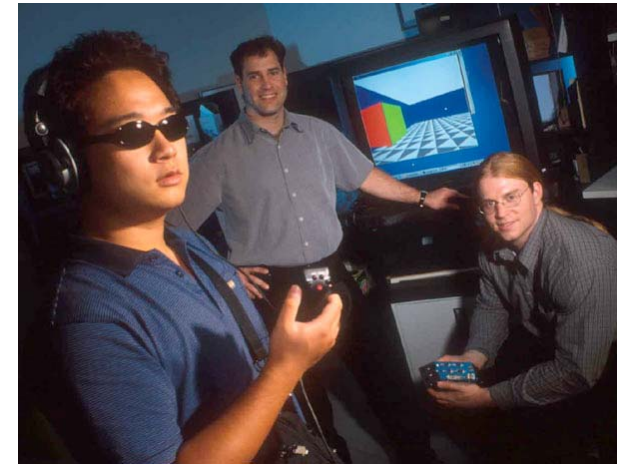
Drishti [\[Helal et al. ISWC 2001\]](#)

- ...basically the same as PGS



Swan [\[Walker 2003\]](#)

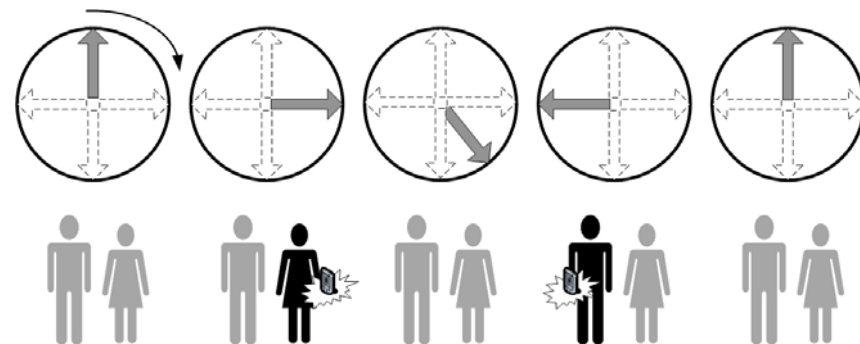
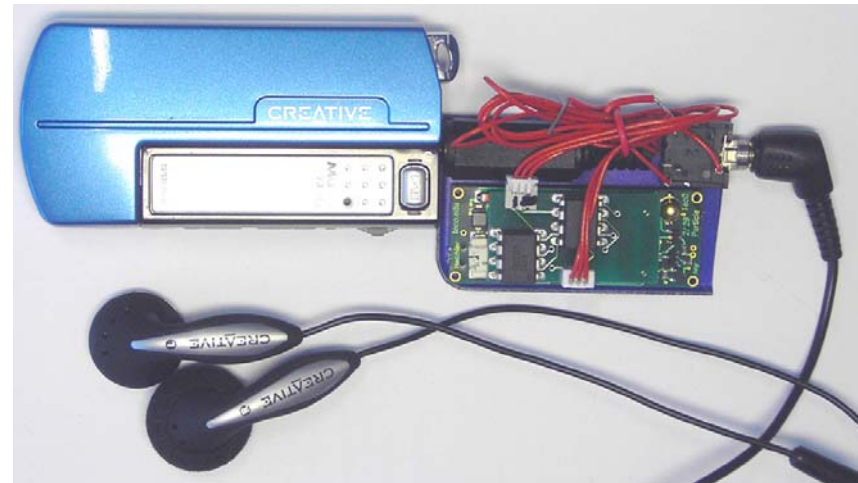
- *Same story again, but:*
- *Non-speech auditory interface*



- *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."

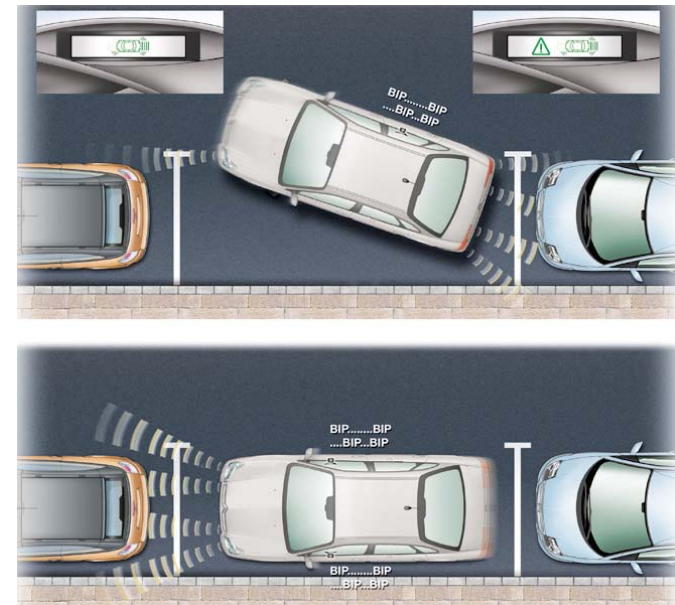
LMU time-multiplexed display

- 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

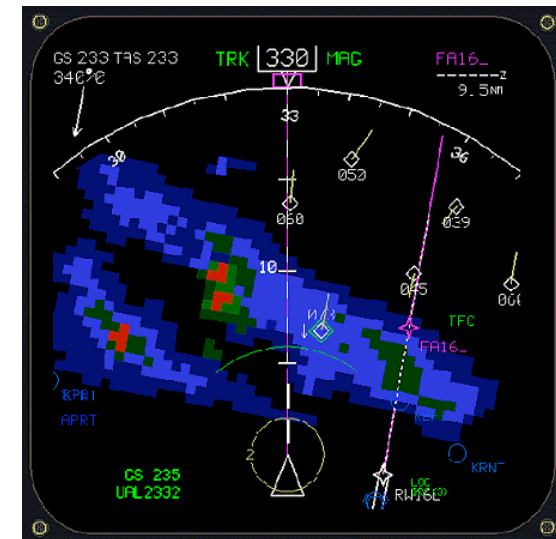
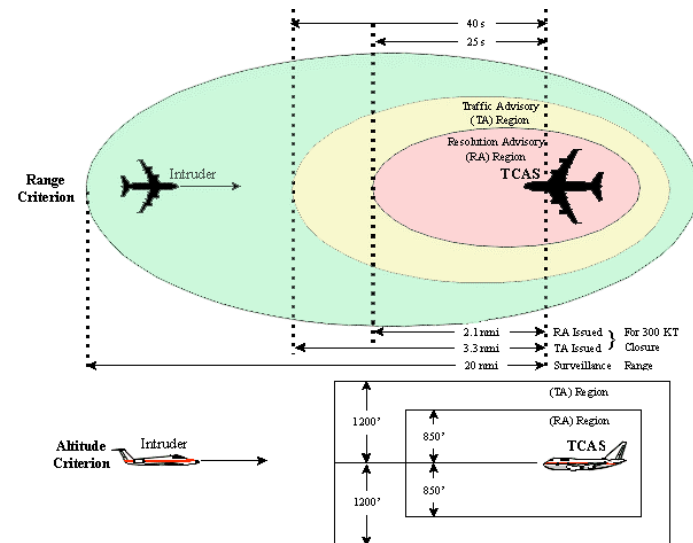
- Sensors in the bumper
 - Detect distance to next car
 - At speeds below 10km/h
- Car Audio system:
 - Plays a beeping sound
 - Frequency corresponds to distance
 - Uses front/back/left/right speakers
 - Direction corresponds to direction ;-)



Virtual Acoustic Enhancement of TCAS

[\[Wenzel et al. at NASA Ames\]](#)

- 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 1. Example of sound design variations between types for email quantity

	Sound Effects	Music	Voice
Nothing new	a single gull cry	high, short bell melody, rising pitch at end	"You have no email."
A little (1 - 5 new)	a gull calling a few times	high, somewhat longer melody, falling at end	"You have n new messages."
Some (5 - 15 new)	a few gulls calling	lower, longer melody	"You have n new messages."
A lot (more than 15 new)	gulls squabbling, making a racket	longest melody, falling at end	"You have n new messages."

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 [\[Walker, 2004\]](#)

Threshold	Type	Sound Generated
+1.60%	Random/ Hit	Large cricket calling at 2 samples per minute
+1.50%	Random/ Hit	Roadrunner calling at 1 sample per minute
+1.00%	Random/ Hit	Cicada singing at 1 sample per minute
+0.75%	Random/ Hit	Cuckoo calling at 1 samples per minute
+0.50%	Random/ Hit	Small cricket singing at 2 samples per minute
+0.25%	Random/ Hit	Bullfrog croaking at moderate tempo – 1 sample per minute
0.00%	Loop	River at normal gain, speed, and tempo
-0.50%	Loop	Light rain begins
-1.00%	Loop	Heavy rain (multiple overlapping samples, increased gain)
-1.50%	Random/ Hit	Thunder crashes at 1 sample per minute
< -1.60%	Random/ Hit	More violent thunder at 1 sample per minute

Tactile augmentation

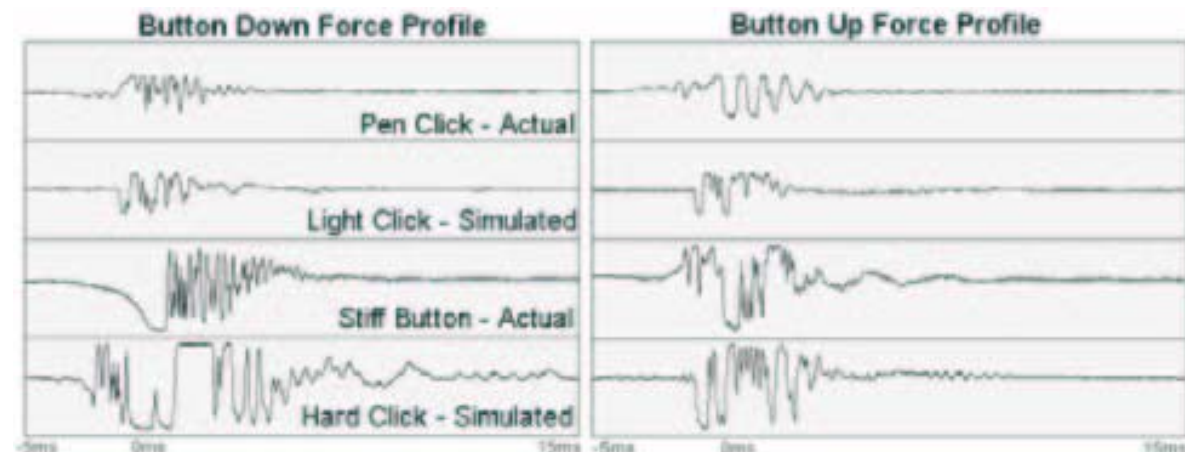
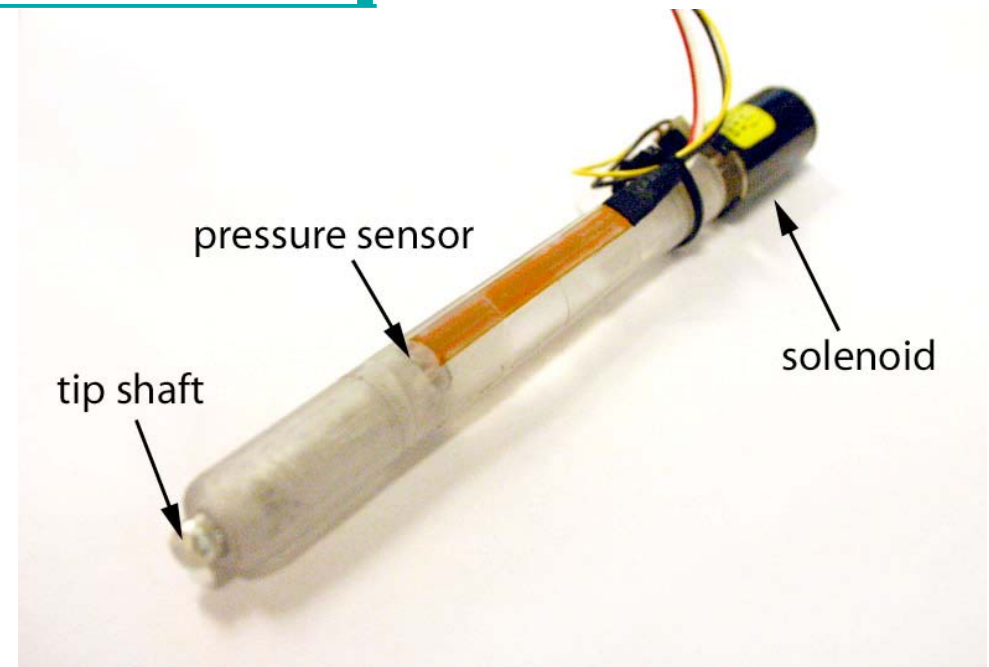
Tactile pen interfaces

Wearable tactile devices

Tactile augmentation in cars

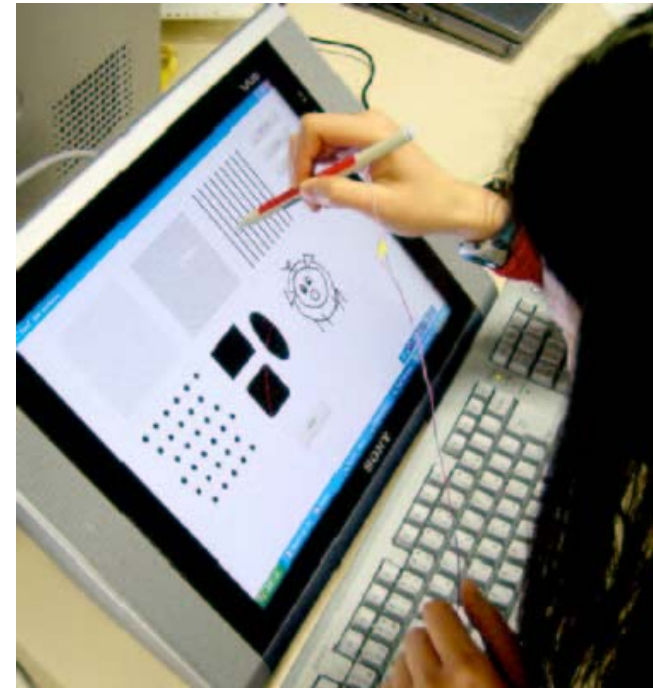
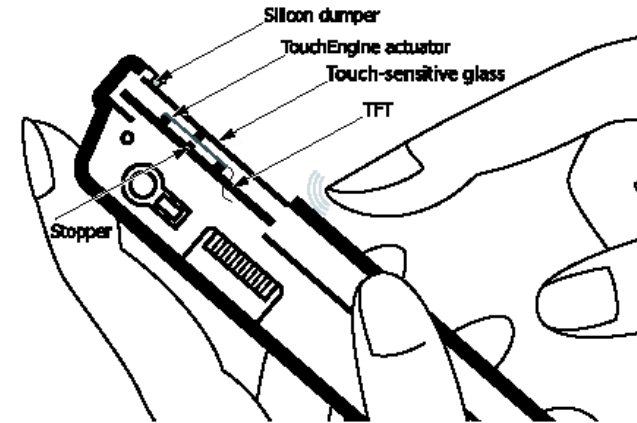
Haptic Pen: [\[Lee et al. UIST 2004\]](#)

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



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



TNO Tactile Vest [\[van Erp & van Veen, Eurohaptics 2003\]](#)

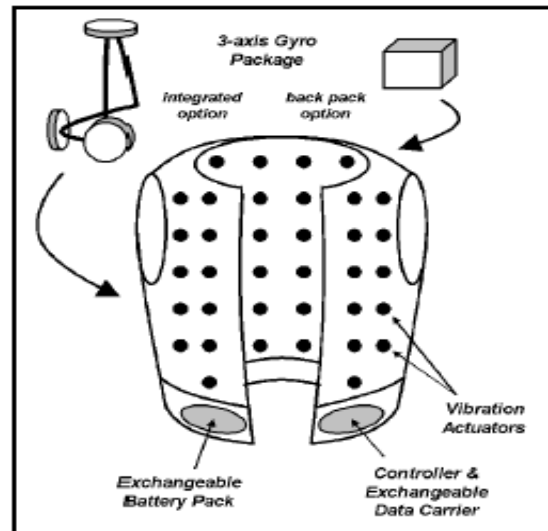


Fig. 1. Schematic lay-out of the multi-purpose vibro-tactile vest designed for use in the International Space Station (design by Dutch Space and TNO Human Factors, The Netherlands).

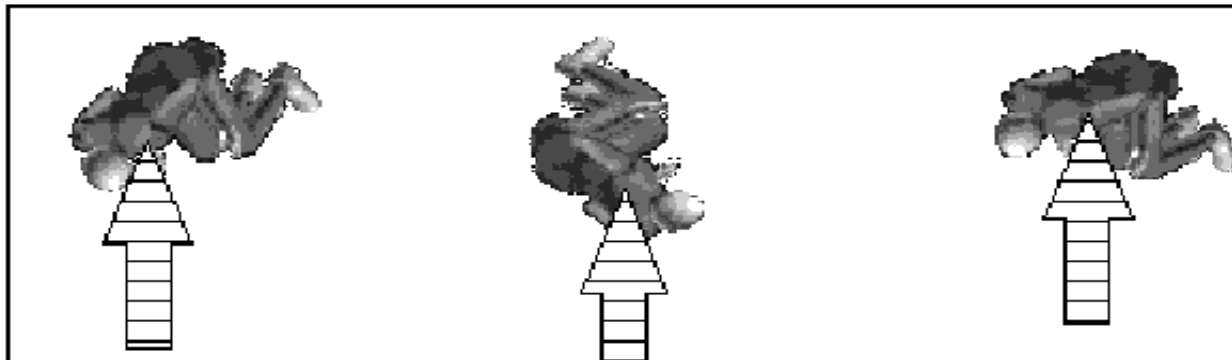
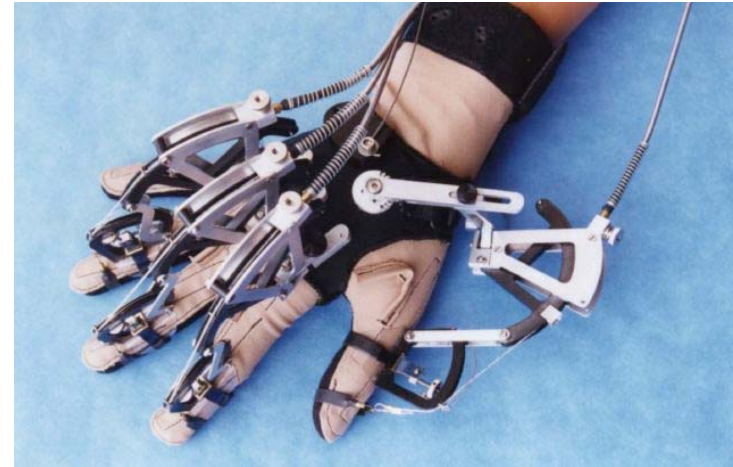


Fig. 2. Principle of projecting the artificial gravity vector as a localised vibration on the torso. A straight-up orientation will lead to no stimulation. For example, when oriented upside-down, the astronaut would receive a vibration on the shoulders. When the astronaut floats horizontally with his belly 'down', the vibration would be on the belly; and when floating on his back, the vibration would be on his back, etc.

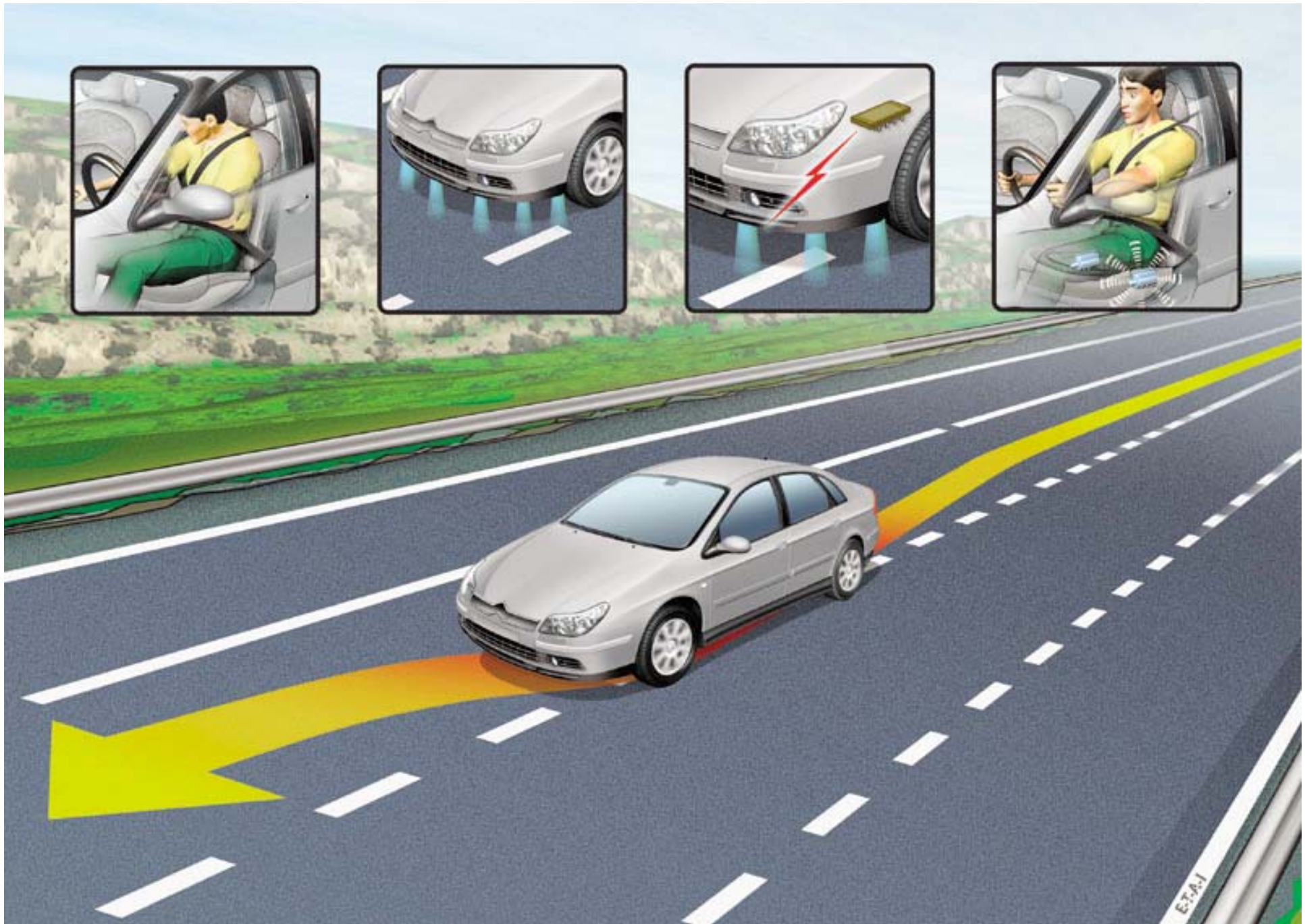
Cybergrasp force feedback glove

- 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



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
- <http://www.citroen.com/CWW/en-US/TECHNOLOGIES/>



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



Olfactory augmentation

Technology of olfactory displays

Application ideas

Current application

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

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/



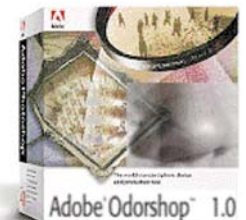
See for examples: <http://www.aromajet.com/game.htm>
and J. Kaye, Making scents: aromatic output for HCI

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.

But: <http://www.rru.com/webodor/> ;-)



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
- 9 scents available: Agrume Passion, Ambre Santal, Cannelle Gingembre, Fleur de Lotus, Fleur de Vanille, Jasmin Mimosa, Lavande Douce, Menthe Musc et Ylang Bambou.
- Only on french web page ;-)
- <http://www.citroen.com/CWW/fr-FR/TECHNOLOGIES/COMFORT/S-CENTEDAIRFRESHENER/>



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
- Holidays are close