

# 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

# 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 !!!

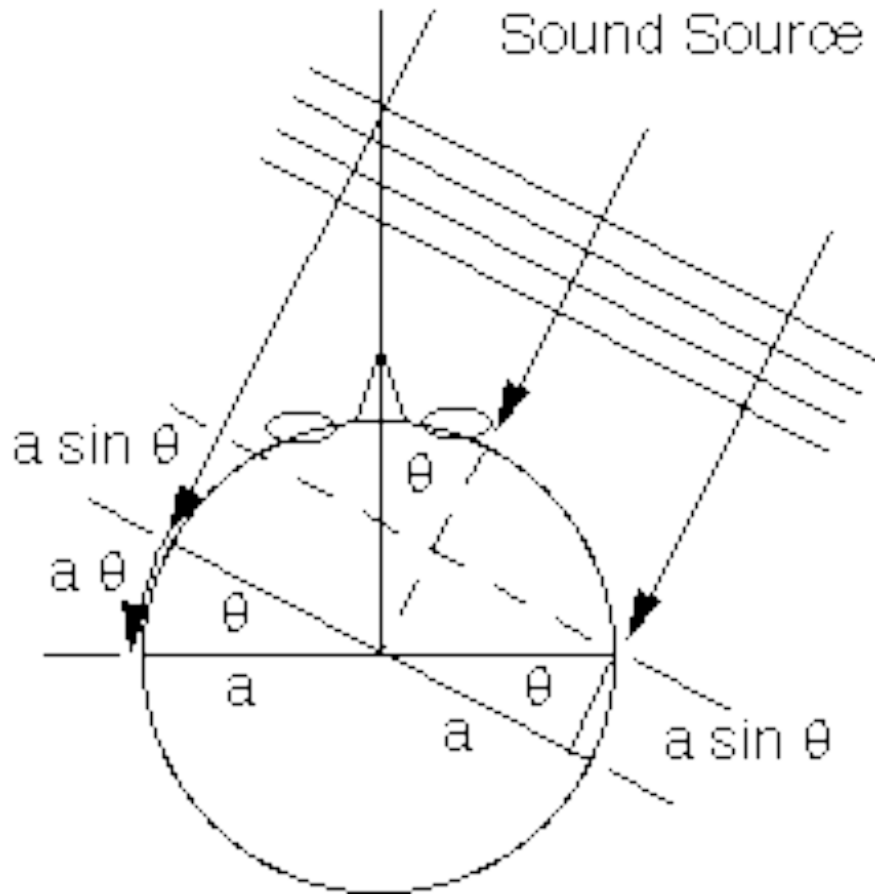
# Acoustic augmentation

Navigation for the blind

Acoustic Ambient UIs

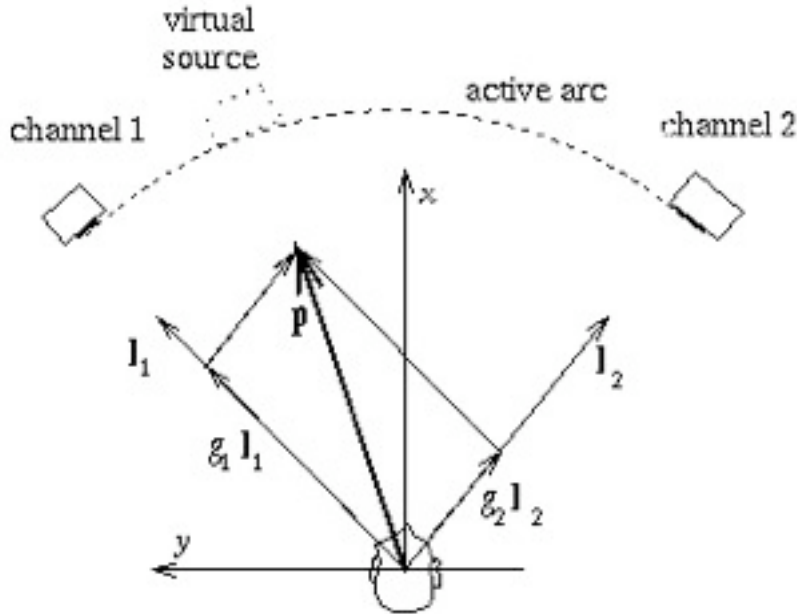
Car parking Aids

# Spatial hearing



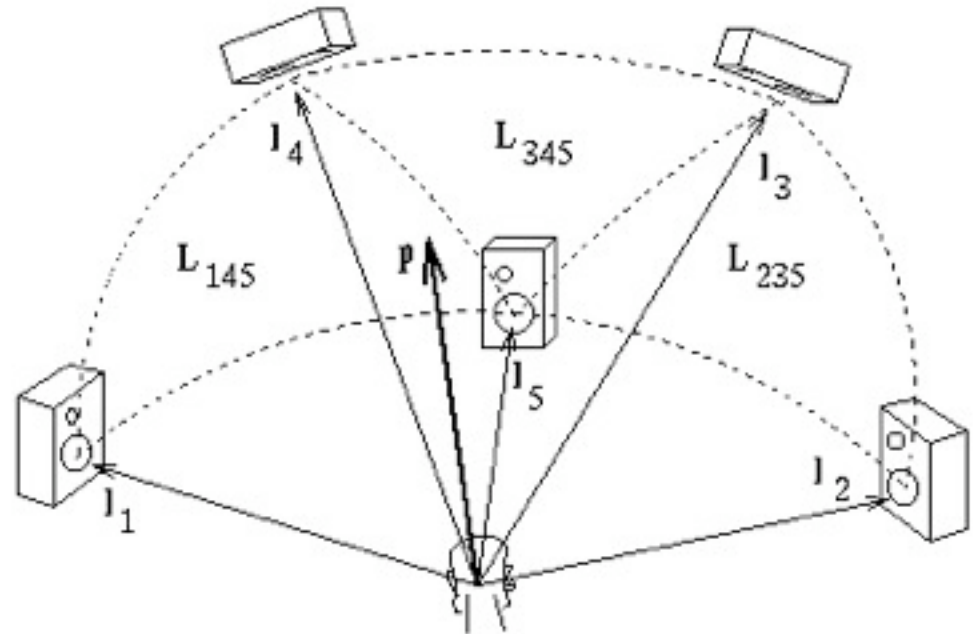
- Caused by:
  - Interaural time difference (ITD)
  - Interaural intensity difference (IID)
  - Head related transfer functions (HRTF)
- Better for high than for low frequencies

# Vector Based Amplitude Panning



$$\underline{p} = g_1 l_1 + g_2 l_2 = Lg$$

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



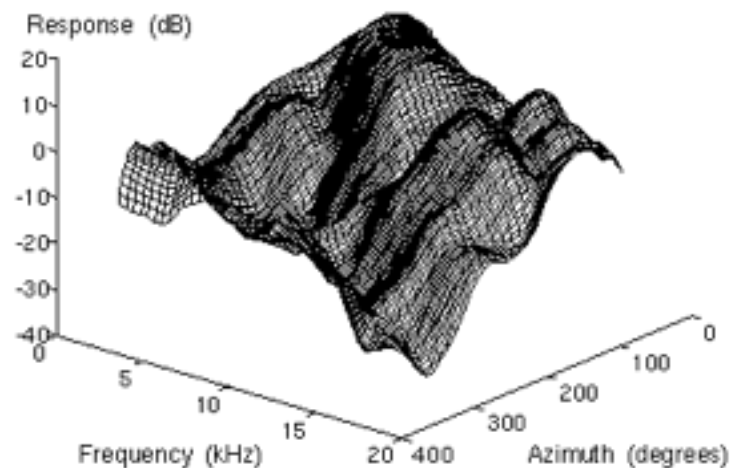
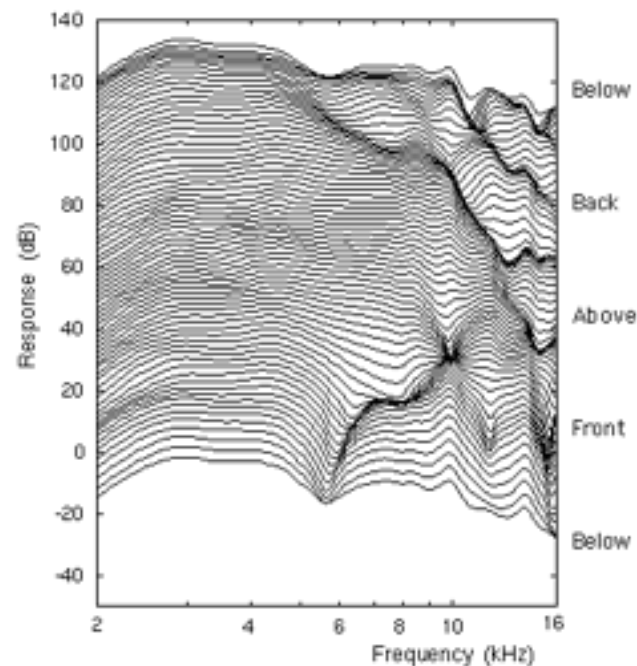
$$\underline{p} = g_1 l_1 + g_2 l_2 + g_3 l_3 = Lg$$

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

➔ 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)

<http://www.geog.ucsb.edu/pgs/current.htm>

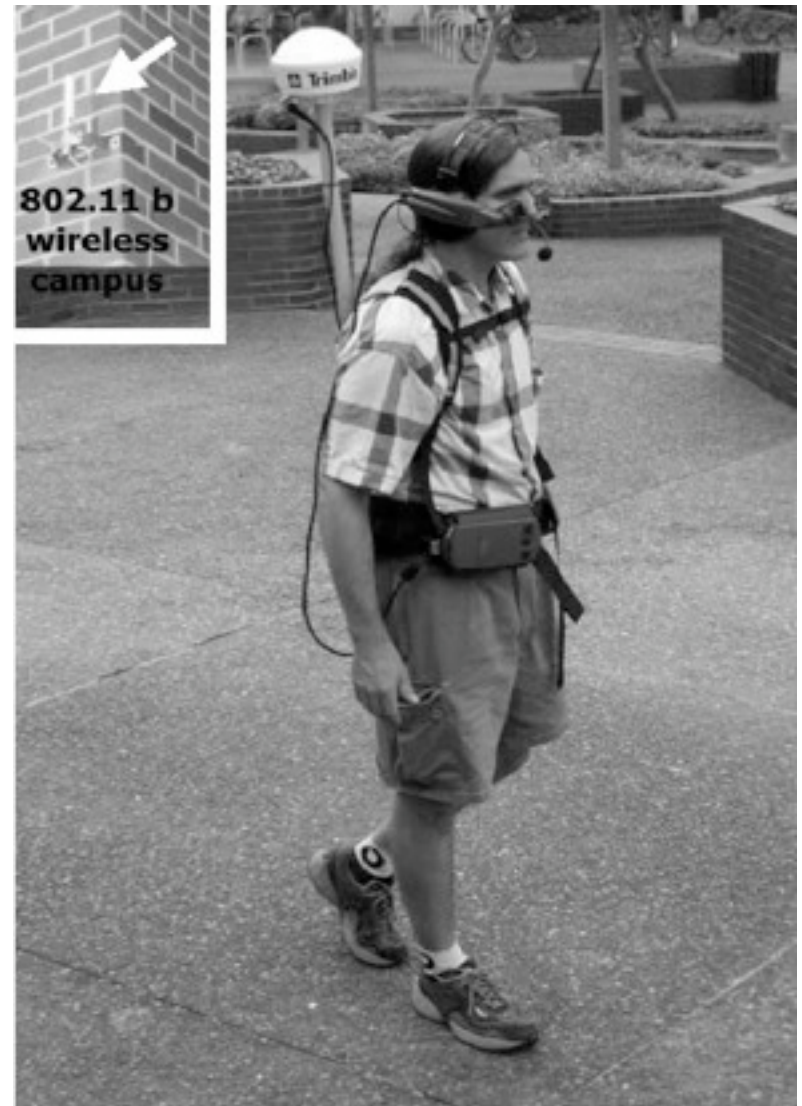
- Pedestrian navigation system for the blind
- Use GPS for tracking
- Issue voice commands over headphones
- Controlled by voice input
- In 2003 the size of a small shoulder bag





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

- ...basically the same as PGS



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

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

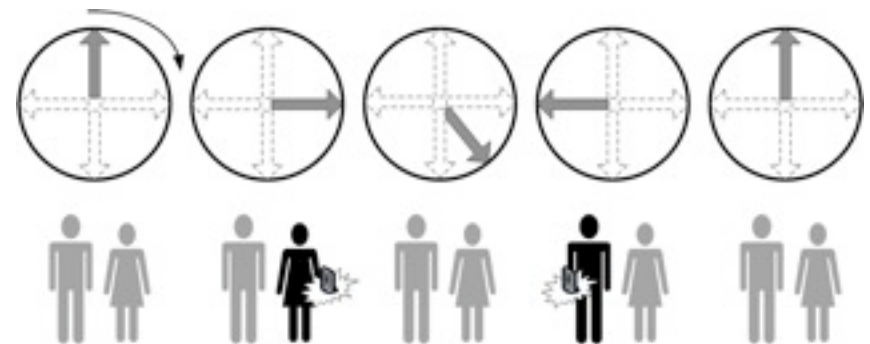
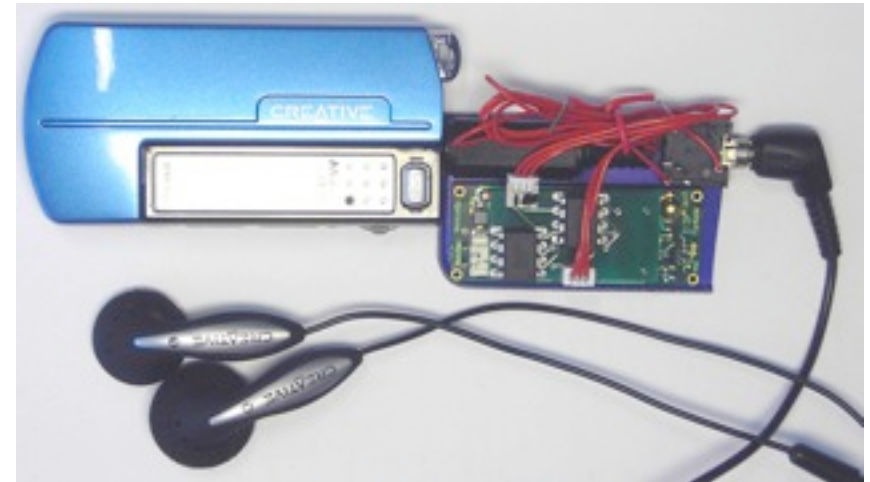


- *Navigation Beacon* sounds guide the listener along a predetermined path, from a start point, through several waypoints, and arriving at the listener's destination.
- *Object Sounds* indicate the location and type of objects around the listener, such as furniture, fountains, doorways, etc.
- *Surface 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,



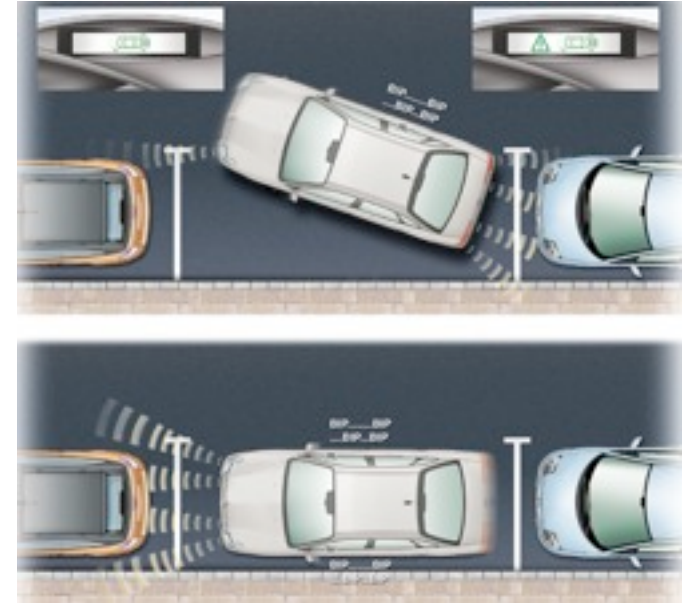
# LMU time-multiplexed display

- 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

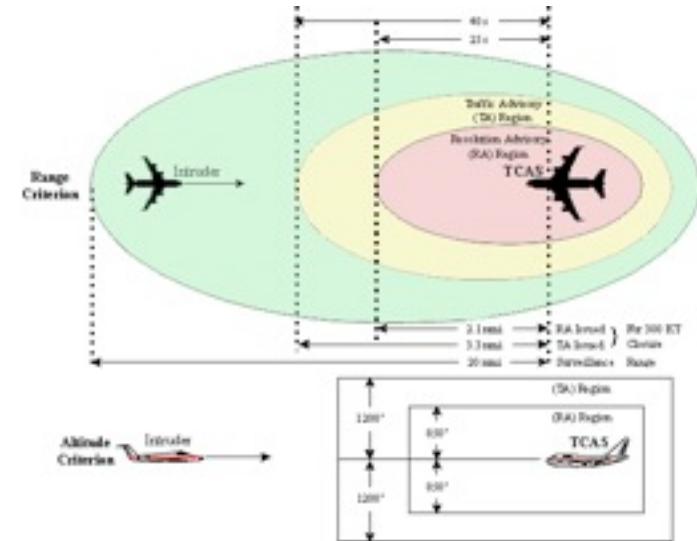
- Sensors in the bumper
  - Detect distance to next car
  - At speeds below 10km/h
- Car Audio system:
  - Plays a beeping sound
  - Frequency corresponds to distance
  - Uses front/back/left/right speakers
  - Direction corresponds to direction ;-)



# 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**

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

# Tactile augmentation

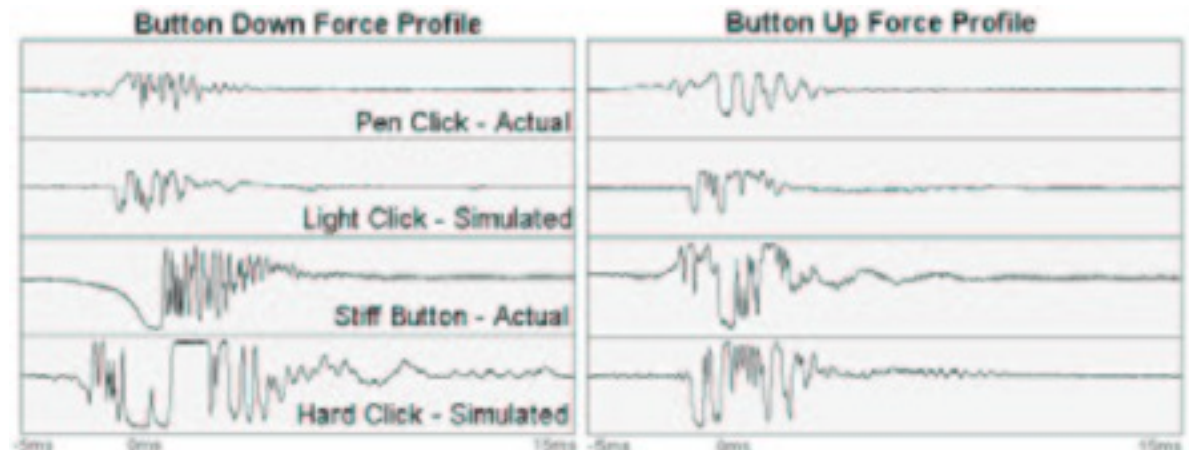
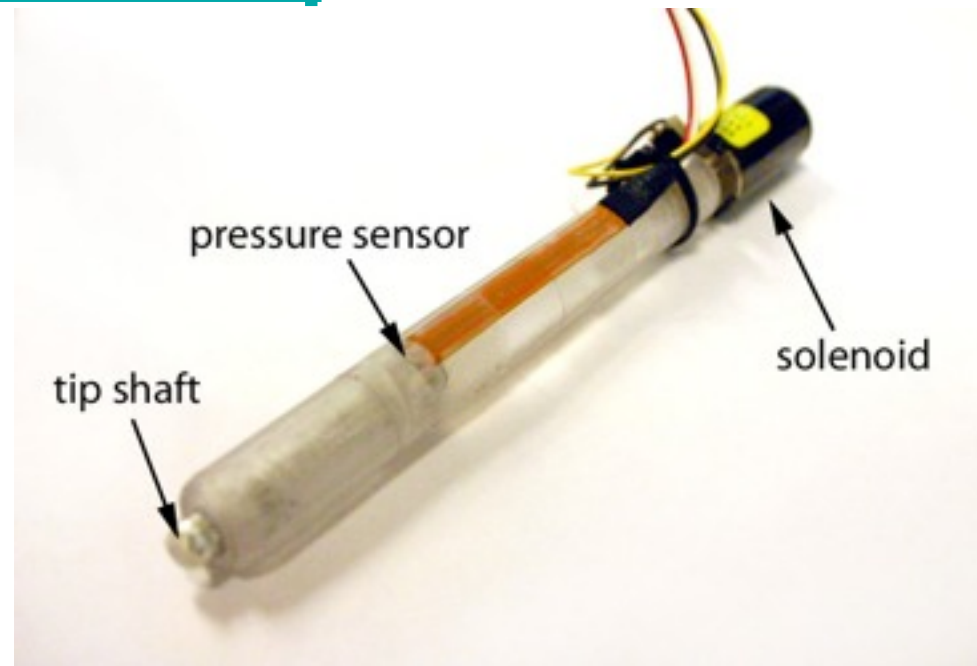
Tactile pen interfaces

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



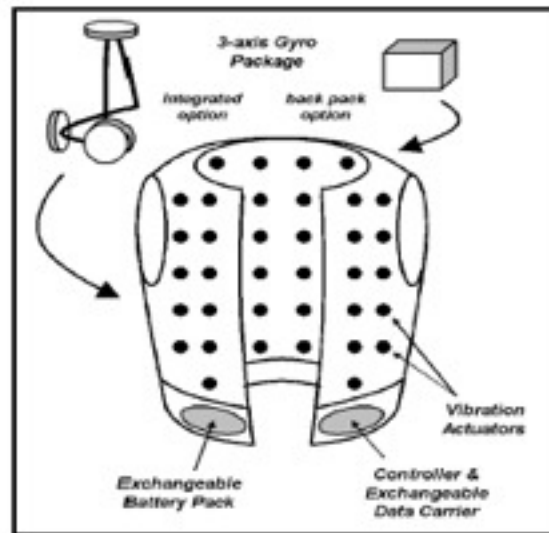
# Ambient Touch [\[Poupyrev et al. 2002-2004\]](#)

- 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

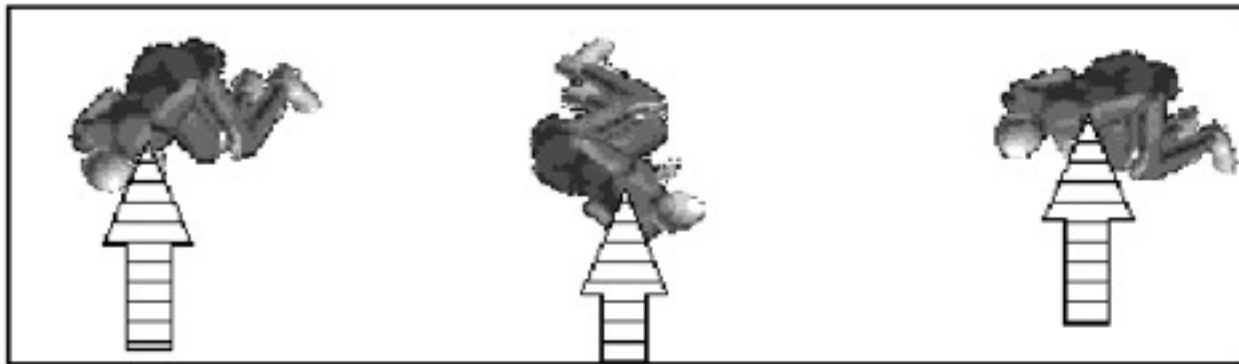




# TNO Tactile Vest [\[van Erp & van Veen, Eurohaptics 2003\]](#)



**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

<http://www.cyberglovesystems.com/>

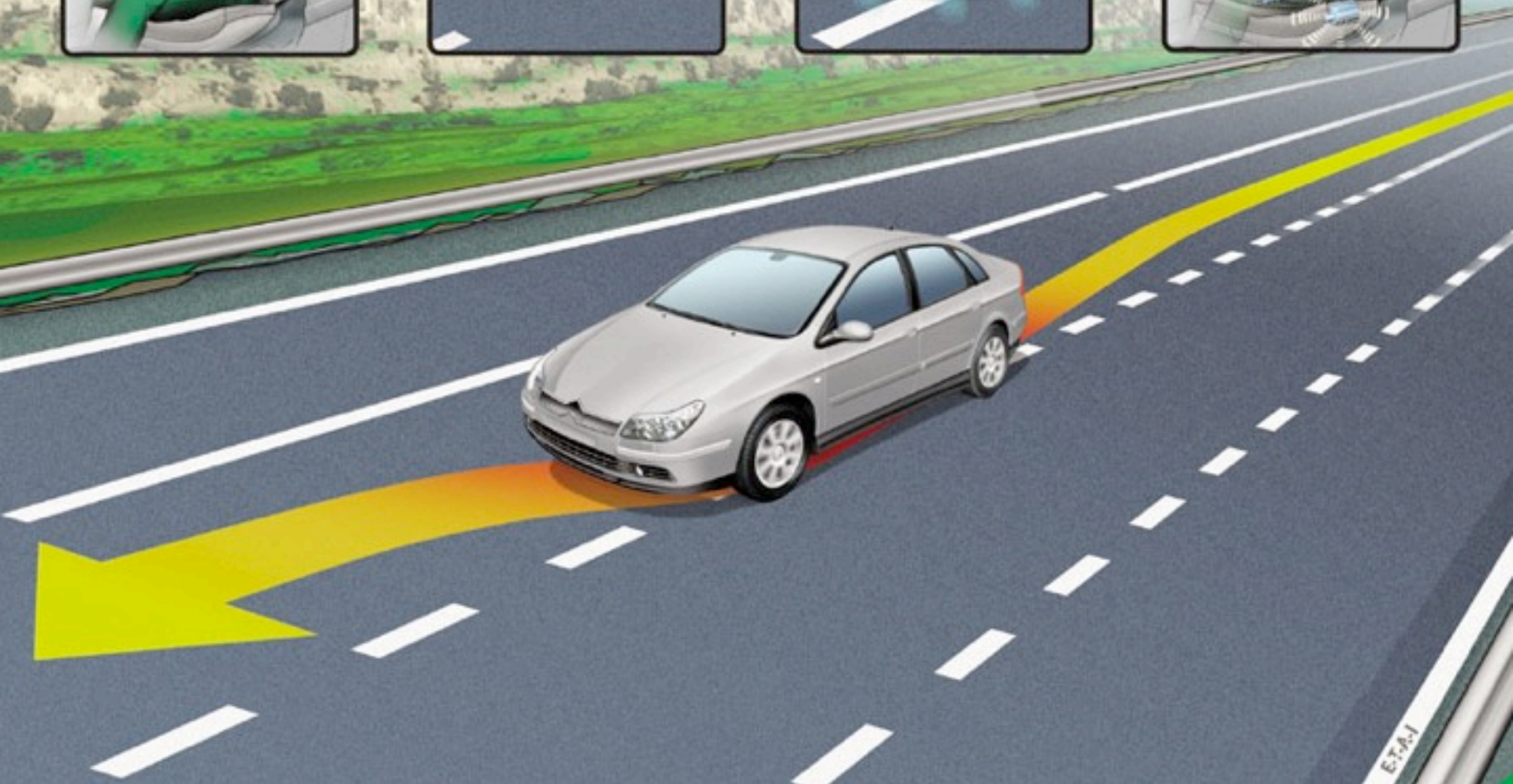
- Mechanical construction (exoskeleton) around hand
- Actuated from a control unit via cables
- Force feedback for each finger
  - Maximum Continuous Force: 12 N per finger
  - Force resolution: 12-bit
  - Weight: 350g
  - Workspace: 1 meter radius
  - Host Interface: RS-232 and Ethernet are supported





# 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.co.uk/technology/safety/ldws/>



# 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/](http://www.scentury5d.com/) Link mittlerweile tot



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.be/Site/Technologie/Confort7.aspx?lang=fr>



# 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
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