Output devices

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1

Outline

- User interfaces – Output
  - Vision / Graphic displays
    - Personal and Large Volume Display
    - Technology: CRT, LCD, e-paper, projector
    - Stereoscopic displays
      - Autostereoscopic
      - HMDs
  - Voice
  - Touch and Force Feedback
  - Taste and Smell

2

2

Many displays for many applications

3

3

Less conventional Displays

4

4

The ultimate display?

"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal."

(Ivan Sutherland, 1965)

We are not there yet…

5

5

Vision / Graphic Displays

"A graphics display is a computer interface that presents synthetic world images to one or several users interacting with the virtual world."

(Burdea and Coiffet., 2003)

• Personal displays:	Main technologies:
- Monitors	LCDs / LEDs
- HMDs	
- Binoculars	
- Monitor-based displays/active glasses	LCDs
- Autostereoscopic displays	lenticular/barrier
• Large volume displays:	
–Workbenches	
– Caves	projectors
– Walls	
– Surface tables (Microsoft, …)	

6

6

Personal Displays

The images may be monoscopic or stereoscopic, monocular (for a single eye) or binocular (displayed on both eyes).

- Screens of various sizes
- Head Mounted Displays (HMDs)
- 3-D Binoculars (hand supported)
- Auto-stereoscopic displays (desk supported)





8

Large-volume displays

- CAVE type displays
- Wall-type displays
- Domes
- ,,,


https://www.tii.se/inside-explorer-at-the-british-museum

http://www.mechdyne.com/cave2.aspx

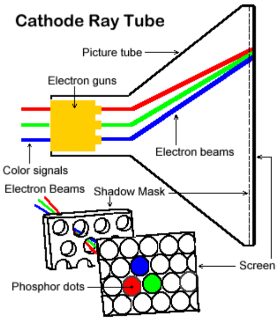
9

Displays main technology

- Main technologies:
  - LED displays (several types)
  - LCD displays
  - Autostereoscopic displays: lenticular/barrier
  - Projectors
- Other technologies: plasma, electrophorectic, electroluminescent displays

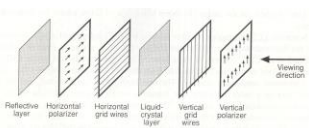
10

CRT

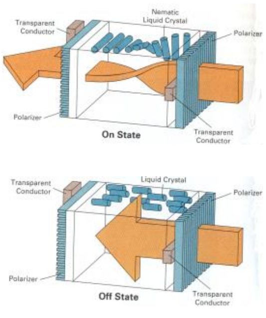


11

LCDs (Liquid Crystal Displays)



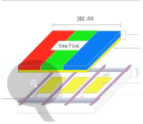
Layers in a early LCD



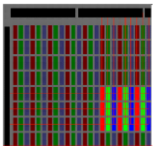
States of a LCD

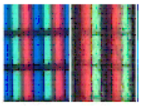
12

Colour LCD



Each pixel corresponds to a triad of colours: RGB





White	Yellow
All on	B off

https://en.wikipedia.org/wiki/Liquid-crystal_display

13

LEDs

LEDs allow *displays*:

- Use a matrix of triads of LEDs
- more efficient
- brighter

than LCDs (no need for backlight)

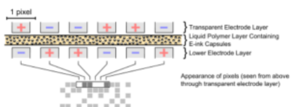
There are variations: OLEDs

Properties of Displays

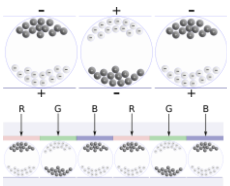
- Diagonal size
- Pixel dimensions & aspect ratio
- Pixel density
- Refresh rate
- Color depth (# colors or grays)
- Color gamut
- Gamma

Electrophoretic displays: “e-paper”

- Form images by rearranging charged pigment particles applying an electric field and reflect light like ordinary paper



https://en.wikipedia.org/wiki/Electronic_paper



- Only consumes power to change display
- Low refresh rate (1-2 Hz), low contrast
- Kindle is 167 ppi, 16 levels grayscale

Commercial devices: Kindle, Nook, ...

- Reflect light like paper
- Very low consumption
- Very low refresh rate
- “Ghosting”

Not very interesting for interactive applications (at least yet)

Electrophoretic displays: “e-paper”

- Also as entry now (Remarkable, etc…)

Stereoscopic displays

Provide stereo images and allow the user to have a 3D sensation

(if they are not autostereoscopic, imply wearing some sort of glasses)

Stereoscopic Vision

What is stereoscopic vision?

Where is it coming from?

Where can you see it or use it?

Stereoscopic vision

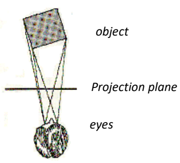
- Many of the perceptual cues we use to visualize 3D structure are available in 2D projections
- Such cues include:
  - occlusion (one object partially covering another)
  - perspective (point of view)
  - familiar size (we know the real-world sizes of many objects)
  - atmospheric haze (objects further away look more washed out)
- Four cues are missing from single 2D views:
  - stereo parallax - seeing a different image with each eye
  - movement parallax -seeing different images when we move the head
  - Accommodation - the eyes' lenses focus on the object of interest
  - Convergence - both eyes converge on the object of interest

Stereopsis

Stereo ="solid" or "three-dimensional"

opsis = appearance or sight

Also: "binocular vision" ,
"binocular depth perception"
"stereoscopic depth perception"



- Stereopsis is the impression of depth that is perceived when a scene is viewed with both eyes by someone with normal binocular vision
- Binocular disparity is due to the different position of our two eyes

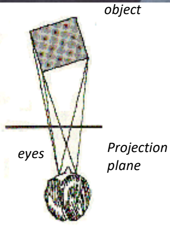
Stereopsis

- Depth perception in stereo is based on stereopsis:
  - when the brain registers and fuses two images
  - Image parallax means that the two eyes register different images (horizontal shift)
  - The amount of shift depends on the "inter-pupillary distance" (IPD) (varies for each person in the range of 53-73 mm)
  - Works in the near field (to a few meters from the eye)

Stereopsis

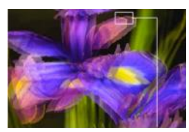
(Hearn and Baker, 2002)

Right eye image *Left eye image*



Stereopsis: implications for Graphic devices

- Need to present two images of the same scene
- The two images can be presented:
  - at the same time on two displays (HMD)
  - time-sequenced on one display (active glasses)
  - spatially-sequenced on one display (auto-stereoscopic displays)



Left eye, right eye images
(Burdea and Coiffet., 2003)

Common ways to produce 3D sensation

- Anaglyphs: two colored images and color coded glasses (red/cyan(green))

- Two images with different light polarization and polarizing glasses
  - Linear and circular

- Double frame-rate displays combined with LCD shutter glasses
- Autostereoscopic displays
  - Parallax barrier and lenticular lens
- Head Mounted Displays (HMDs)
- and "exotic displays"

Graphic Displays – Autostereoscopic displays

- Two technologies:
  - Lenticular
  - barrier

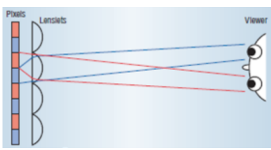
- Do not require use of special glasses
- Allow several vantage points
  - Passive - do not track user's head (restrict user's position)
  - Active - track the head motion (give more freedom)

Graphic Displays – Autostereoscopic displays

Lenticular:

- an array of cylindrical lenslets is placed in front of the pixel raster
- lenslets direct the light from adjacent pixel columns to different viewing slots at the ideal viewing distance

Each of the viewer's eyes sees light from only every second pixel column

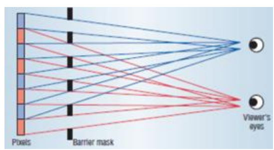


Graphic Displays – Autostereoscopic displays

Parallax barrier:

- a barrier mask is placed in front of the pixel raster

Each of the viewer's eyes sees light from only every second pixel column



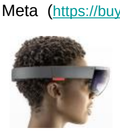
Head Mounted Displays (HMD)

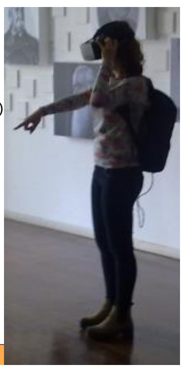
Used in VR/AR

Examples of more affordable devices:

For VR:
Oculus Rift (http://www.oculusvr.com/)
Gear VR (https://en.wikipedia.org/wiki/Samsung_Gear_VR)
HTC Vive (https://www.vive.com/eu/) …

For AR (not as affordable…):
Hololens (https://www.microsoft.com/en-us/hololens)
Meta (https://buy.metavision.com/)





Voice synthesizers

- Several types
  - Digitized – concatenates recorded basic sounds
  - Synthesised – concatenates sounds generated with models
- Several technical challenges due to the nature of human voice
  - different pronunciation rules
  - meaning may be changed by intonation
  - differences in intonation reflect different moods

The quality of a synthesizer implies much more than intelligibility

Voice output – Advantages and Disadvantages

- Advantages of using voice output – user has
  - physical deficiency
  - to move around
  - hands and eyes busy
  - Adverse conditions: low visibility, low O2, high Gs
- Disadvantages:
  - Is tiresome and uncomfortable for long periods
  - Is transient (overload STM)
  - May have privacy issues
  - May disturb other people

32

Voice output – Examples

- Siri
- Google Duplex

Duplex is a culmination of various efforts over the years in deep learning, natural language understanding, speech recognition, and text-to-speech.

https://www.cnet.com/how-to/what-is-google-duplex/

33

Voice output - Guidelines

- Consider voice output as an alternative when the user must move around, has hands and eyes busy
- Avoid voice output in open environments, when the privacy and security are important issues and frequency of usage is high
- Use approx. 180 words per minute
- When messages are not expected, start with non-critical words that provide context
- Say first the goal and then the solutions
- Allow messages to be repeated

34

Touch

Touch Feedback
- Relies on sensors in and close to the skin
- Conveys information on contact surface geometry, roughness, slippage, temperature
- Does not actively resist user contact motion
- Easier to implement than force feedback

35

Touch

Force Feedback:
- Relies on sensors on muscle tendons and bones/joints proprioception
- Conveys information on contact surface compliance, object weight, inertia
- Actively resist user contact motion
- More difficult to implement than touch feedback

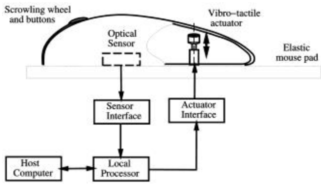
36

Touch Feedback Interfaces

Can be desktop or wearable (gloves)
- Touch feedback mouse
- Force feedback joysticks
- CyberTouch glove
- Temperature feedback actuators

37

The iFeel Mouse (~2000, not in production)



(Burdea and Coiffet, 2003)

38

CyberTouch Glove (Virtex)

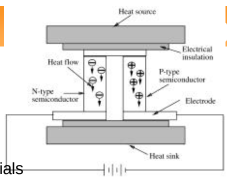
6 individually Controlled Vibrotactile actuators

0-125 Hz frequency
1.2 N amplitude at 125 Hz

39

Temperature feedback

- Added simulation realism by simulating surface thermal "feel"
- Single pump can produce 65°C differentials
- Uses thermoelectric pumps made of solid-state materials sandwiched between "heat source" and "heat sink"
- No moving parts



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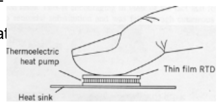
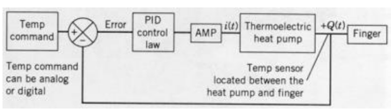
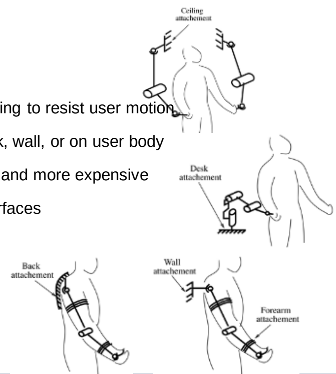




40

Force Feedback Interfaces

- Need mechanical grounding to resist user motion
- Can be grounded on desk, wall, or on user body
- More difficult to construct and more expensive
- Than tactile feedback interfaces

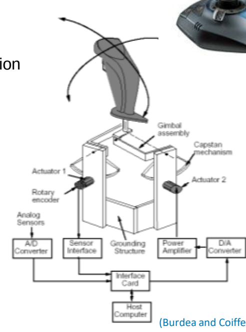


(Burdea and Coiffet, 2003)

41

Force Feedback Interfaces: Logitech 3D

- Uses potentiometers to sense position in spherical coordinates
- Uses electrical actuators to apply resistive torques
- ~$100



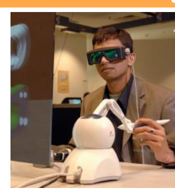
(Burdea and Coiffet, 2003)

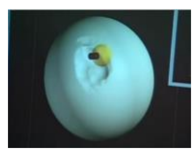
42

Force Feedback Interfaces: Geomagic Touch (former PHANToM Omni)

- Main application:
medical simulations and training exercises in which the stylus emulates physical sensations (puncturing, cutting, probing or drilling) of using a syringe, scalpel, arthroscope or other instrument

- Other commercial, and scientific applications:
  - Robotic Control
  - Virtual Reality
  - Teleoperation
  - Training and Skills Assessment
  - 3D Modeling
  - Applications for the Visually Impaired
  - Entertainment
  - Molecular Modeling
  - Rehabilitation
  - Nano Manipulation, ...
- Haptic devices vary according to workspace size, force, DOFs, inertia and fidelity



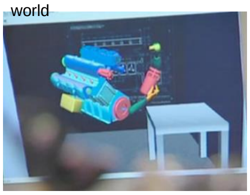


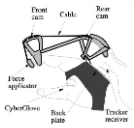
http://www.youtube.com/watch?v=0_NB38m86aw

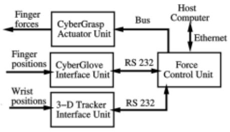
43

Force Feedback Interfaces: CyberGrasp force feedback glove

- Force-reflecting exoskeleton that fits over a CyberGlove data glove
- Adds resistive force feedback to each finger
- Allows users to feel the size and shape of computer- generated 3D objects in a virtual world







(Burdea and Coiffet., 2003)

Smell

- Importance of smell:
  - Commonly accepted that influence how we act and fell
  - Can stimulate memorization
  - Can enhance sense of presence by recalling experience and modifying emotional state.
- Taste:
  - Useful as interaction modality? Unexplored research area.
  - Important role in perceiving the world

Smell

- Google nose beta: https://archive.google.com/nose/

Smelling Interface

- Contains different odorants and a system to deliver them through air and a control algorithm to determine the mix of odorants, its concentration and the time of the stimulus.
- Smelling Screen (Matsukura, Yoneda, & Ishida, 2013) delivers odorants through a four fans system in arbitrary positions of the screen.

Taste Interfaces

- only marginally addressed and few taste interfaces can be found in literature.
- Iwata, Yano, Uemura, & Moriya, 2004 Food simulator addresses chewing simulation
  - releasing flavoring chemica
  - resistance to the mouth
  - Playing sound

"Taste is very difficult to display because it is multi-modal sensation composed of chemical substance, haptics and sound"

Multi sensory

- MASSIVE (Multimodal Acknowledgeable multiSenSory Immersive Virtual Environments)
- sight, hearing, smell, taste and touch
  - tracking system,
  - wind simulation system,
  - smell delivery system.

https://www.inesctec.pt/en/projects/massive#about
https://massive.inesctec.pt/

Hardware@deti - Output

- I-glasses SVGA HMD [2004 - 800€]
- VR 2000 HMD [2012 - 1359€]
- Oculus DK1 [2014 - 420€]
- Oculus DK2 [2015 - 500€]
- Gear VR + Game Pad [2016 - 250€]
- Samsung Galaxy S7 [2016 - 650€]
- Meta Glasses [2018 - 1800€]
- HTC VIVE [2016 - 1350€]

51

Hardware@deti - Output

- I-glasses SVGA Head Mounted Display
- VR2000 HMD

52

Hardware@deti - Output

- Samsung Gear VR + Galaxy S7 + Game Pad
- Google cardboard (without mobile phone)

53

Hardware@deti - Output

- Oculus Rift 1 and 2

54

Hardware@deti - Output

- Meta Glasses

55

Hardware@deti – Input & Output

- Steam VR

56

Conclusion

- Technology shall not be used only because it is new!

  “WOW EFFECT”

- Independently from the type or State of the art of the input / output devices it is necessary to understand their usability for different types of users, tasks and context

•5

57

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58

58