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Output devices

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 yet there …

There are a lot output devices for a lot of different applications
Visual displays:

less conventional displays…

Graphics/visual Displays

Are computer interfaces that present images to one or several users
A possible taxonomy:

- Personal displays:
  - monitors
  - HMDs (VR/AR)
  - Monitor-based displays/active glasses
  - Autostereoscopic displays

- Large volume displays:
  – Caves
  – Walls
  – Domes
  –…

Personal Displays

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

- Screens of various sizes

- Wearable Displays

- Hand-held

- Auto-stereoscopic displays
  (desk supported)

Large-volume displays

- CAVE type displays
- Wall-type displays
- Domes
- …

https://steantycip.com/vr-cave/

Main technologies:

- LED displays (several types)
- LCD displays (older)
- Autostereoscopic displays: lenticular/barrier
- …

- Other technologies:
  electrophorectic,…

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

- **Images provided by computer monitors are poor when compared to the real world**

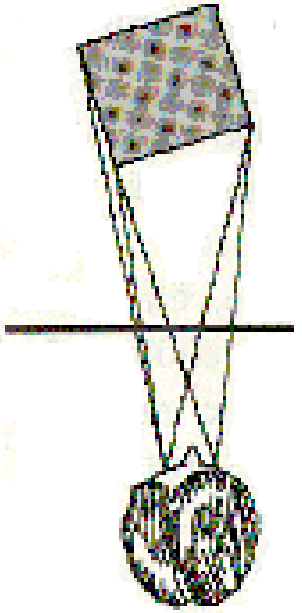
- **It is amazing what we get from such simple devices**

- Monitors have several limitations:
  - Small range of intensities and colors
  - Lack of focusing distance
  - Small field of view
  - ...

Stereoscopic displays

Two images for the two eyes provided by a HMD (Head-Mounted Device)

Right eye image *Left eye image*



- Need to present **two images** of the same scene (one for the **right eye** and another for the **left eye**)

- 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)

Curious about the future of visual displays?

https://www.lightfieldlab.com/watch-how-it-works

Xiong, J., Hsiang, EL., He, Z. *et al.* Augmented reality and virtual reality displays: emerging technologies and future perspectives. *Light Sci Appl* **10,** 216 (2021). https://doi.org/10.1038/s41377-021-00658-8

A glimpse of the future? Interactive live holography

http://realviewimaging.com/technology/

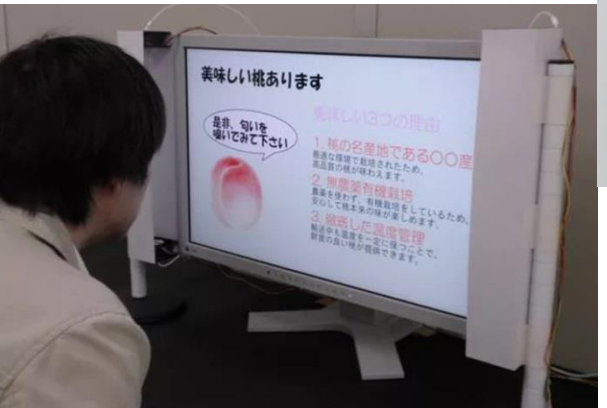
And not only to produce visual displays…

https://www.3dsystems.com/haptics-devices/touch

sound

Touch and force feedback

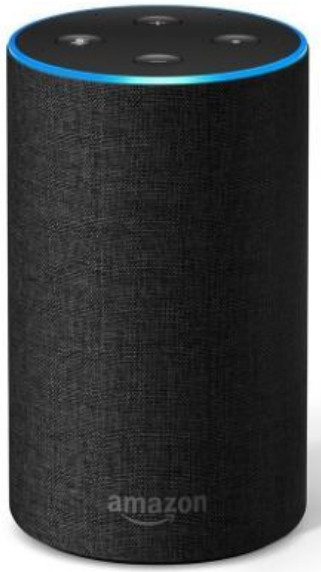
smell



https://vrscout.com/news/olfactory-engineering-scent-based-vr/

Examples of using voice input/output and natural language interaction style:

- Siri
- Alexa
- Google Home
- Google Duplex



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

Voice synthesizers

- There are several types:

  Digitized - concatenates recorded basic sounds

  Synthesised – concatenates sounds generated with models

- There are 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**

Advantages of using voice output:

When the user has:

- physical deficiency
- to move around
- hands and eyes busy
- Adverse conditions: low visibility, low O_2, high Gs

Disadvantages:

- Is tiresome and uncomfortable for long periods
- Is transient (taxes STM)
- May have privacy issues
- May disturb other people

Some guidelines to use voice output

- 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

Every year new devices appear

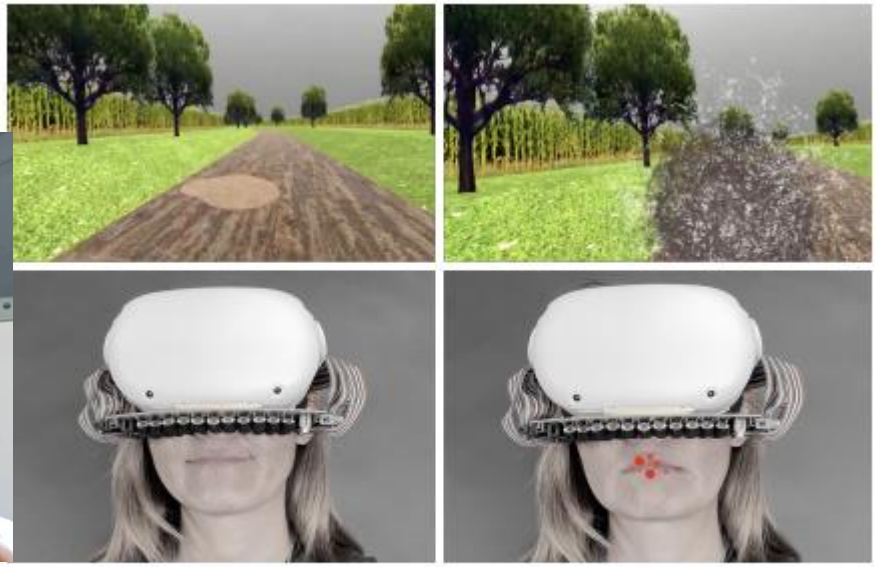
- Some are really weird …

Haptic System Creates Finger-Touch Sensations Hardware-Free - IEEE Spectrum

- Some never go beyond experimental research

- But once in a while a few become wide-spread

Another example:



Splashing into a puddle, which triggers a series of short random impulses.

[Mouth Haptics in VR using a Headset Ultrasound Phased Array | Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (acm.org)]

https://www.youtube.com/watch?v=3q6dZQfV1x8

Conclusion

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

- **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**