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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:  
electrophoretic,...



[https://en.wikipedia.org/wiki/E\\_Ink](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



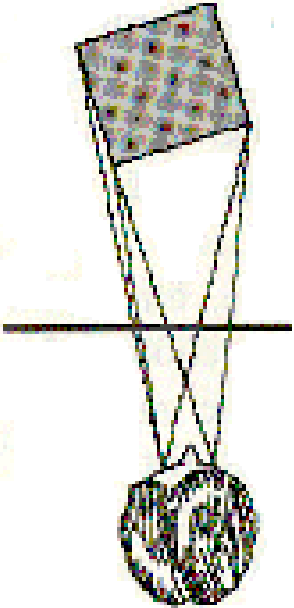
Two images for the two eyes provided by a HMD (Head-Mounted Device)



Right eye image    Left eye image

Projection plane

eyes



object

- 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...

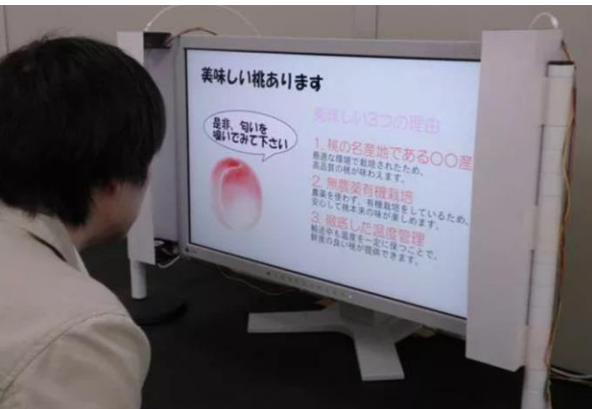


sound



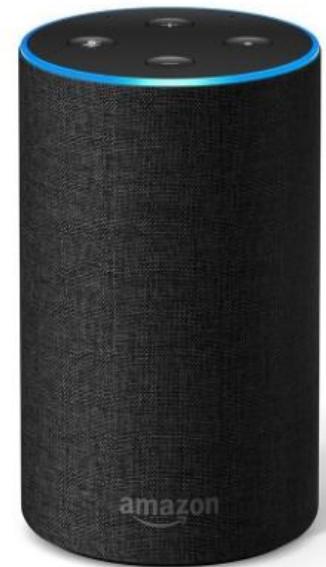
Touch and force feedback

smell



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

- Siri
- Alexa
- Google Home
- Google Duplex



[https://en.wikipedia.org/wiki/Amazon\\_Alexa](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<sub>2</sub>, 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 one in a while a few become wide-spread

# 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**