



Learning Goals

- Understand …
 - Technical parameters for visual displays
 - The impact of display resolution on the user experience
 - The benefits and issues of large screen setups

Know

- How 3D content can be presented
- About different technologies that can be used to create a real 3D output

Visual Display: Screens

Technical Parameter

- Display technology (e.g. LCD, LED, OLED)
- Size (physical size, often the diagonal in inch, e.g. 65")
- Aspect ratio (width:height, e.g. 4:3, 16:9, or 21:9)
- Resolution (number of pixel, width x height, e.g. 1920x1080)
- Pixel density (how close are pixels together, size of pixels, pixels per inch, dots per inch, e.g. 320ppi)
- Color depth (how many colors, per color, e.g. 8-bit / 10-bit)
- Color gamut (which colors)
- Mechanisms for color calibration
- Refresh rate (related to images per second, 100Hz, 200Hz)

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Visual Display: Screens

Aspect ration and resolution examples



"Retina Display"

A resolution that your eyes cannot see the pixels

- Example iPad 2 vs. iPad 3
 - 1024 × 768 pixel (132 ppi) vs. 2048 × 1536 pixel (264 ppi)



- Angular resolution of the eye is about 1 arcminute ~ 0.02°
- Assume the following viewing angle:
 - 60° ~ requires 3.000 pixel
 - 120° ~ requires 6.000 pixel
- ... hence 8K will be enough (with a reasonable viewing distance).

- Traditionally 72dpi (Apple) and 96dpi (Windows)
- Rapid change in the last years



Visual Output

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How does it impact the user?

- Three Tasks: image search, word counting, video analysis
- 16 participants, four Screen Resolutions



Lischke, L., Mayer, S., Wolf, K., Sahami Shirazi, A., & Henze, N. (2015, April). Subjective and objective effects of tablet's pixel density. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 2769-2772).

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How does it impact the user?

- Measured by questionnaire
- Rating mental effort on SMEQ-Scale
- Rating media quality on ITU-T P.910
- Measurement
- Distance between eyes and tablet
- Task completion time

Errors



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Visual Output

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How does it impact the user? Perceived Quality

Perceived Quality



Perceived Effort

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Absolute Screen Space is Useful!

It is easier to move your gaze than to bring windows to the front, move between tabs, or scroll!

- Many tasks benefit: comparison, overview, multiple documents...
- Issues with large screens:
 - Finding the mouse cursor
 - Moving the mouse
- Practices
 - Working local in one region
 - Periphery for other documents



E-Paper vs. Paper Displays, other displays

60x magnification, 10-12 pt font





Visual Output

Albrecht Schmidt

More Visual Display Technologies

Projection

- Key aspects
 - Resolution
 - Brightness (daylight, outdoors)
 - Noise
 - Projection distance
 - Lens and image correction
 - Connectivity
 - Size and weight

E-paper Displays

- Slower update rate
- Black and white or few colors
- Readable outdoors
- Require light (like paper)



3D-Displays

Requirements

- Different images
- One image per eye







Visual Output

Albrecht Schmidt

3D View on a 2D Canvas & Displays

Everything on a 2D display is 2D!

- If we see it three dimensional we imagine it...
- Expectations and experience as basis
- Displaying a projection of a 3D model
- "Options to visualize 3D graphics
 - Create a 2D image that the user translates to 3D in his head
 - Provide images (that represent a 3D model from a particular view point) for both eyes
- Monocular cues (perceived with a single eye)
 - Visual angle indicates how much of view object occupies
 - Familiar objects perceived as constant size
 - Overlapping help perception of size and depth



Real 3D requires an image for each eye

- Real physical objects
- Providing a display for each eye (headset)
- Overlaying images an separating them for each eye
 - Time synchronized, e.g. shutter glasses
 - Polarization filter on projector and glasses
 - Color anaglyph systems
- Autostereoscopic displays
- Volumetric displays

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User Psoreilly on en.wikipedia (CC BY-SA)

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Tovi Grossman, Daniel Wigdor, and Ravin Balakrishnan. 2004. Multi-finger gestural interaction with 3d volumetric displays. In Proceedings of the 17th annual ACM symposium on User interface software and technology (UIST '04). ACM, New York, NY, USA, 61-70.

Swept-screen multiplanar volumetric display

- 198 2-D slices
- 768 x 768 pixel slice resolution
- 100 million voxels
- 24 Hz volume refresh
- Viewing Angle: 360° horizontal, 270° vertical

Did you understand this block?

Can you answer these questions?

- Discuss technical parameters that are relevant for visual displays?
- What is the difference between a tablet screen and an e-paper display with regard to different parameters?
- How does an autostereoscopic display work?
- How does the shutter technology work in principle?
- Why can we "see" 3D images on 2D screens?



Reference

- Lischke, L., Mayer, S., Wolf, K., Sahami Shirazi, A., & Henze, N. (2015, April). Subjective and objective effects of tablet's pixel density. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 2769-2772).
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