3D Display Technologies summary

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Artificial Intelligence & Information Analysis Lab

Overview

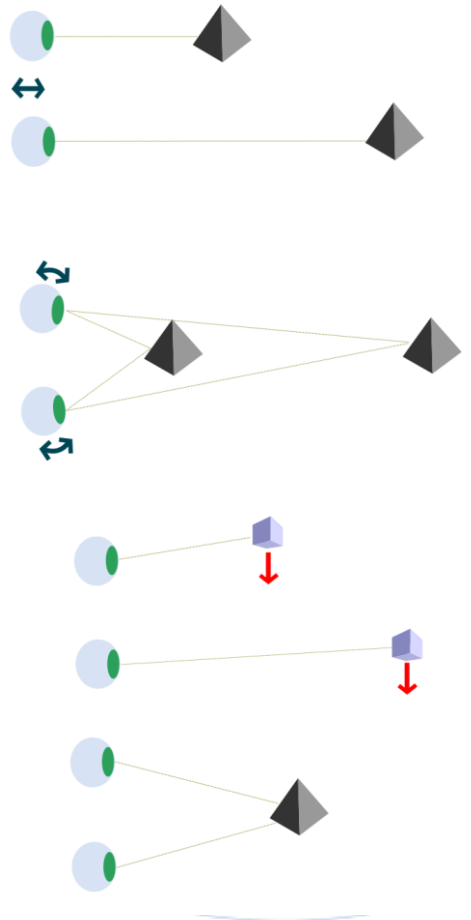
- Human stereo vision
- Color-encoded stereo display (anaglyph)
- Polarization-encoded stereo display
- Time-multiplexed stereo display
- Wavelength-multiplexed stereo display
- Head-mounted displays
- Free viewpoint 3D display (Autostereoscopy)
- Holographic displays
- Lenticular displays
- Volumetric image displays

The ideal 3D Display

- Provides all the cues the Human brain uses to perceive depth.
- A scene reproduced in the 3D display should be perceived as the real one observed by a window of the same size.

Human vision depth cues

- Accommodation
- Convergence
- Parallax
- Binocular disparity



3D image projection / display categories

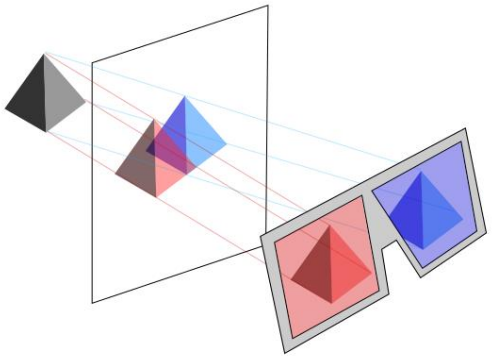
- **Aided viewing**: Requires special equipment (e.g. glasses, goggles etc.) to separate and project the image to each eye.
- **Free viewpoint**: No equipment is interposed between the image source and the human eyes.

Aided viewing

- Color-encoded stereo image.
- Polarization-encoded stereo image.
- Time-multiplexed stereo image.
- Wavelength-multiplexed stereo image.
- Stereo image by spatially separated views.

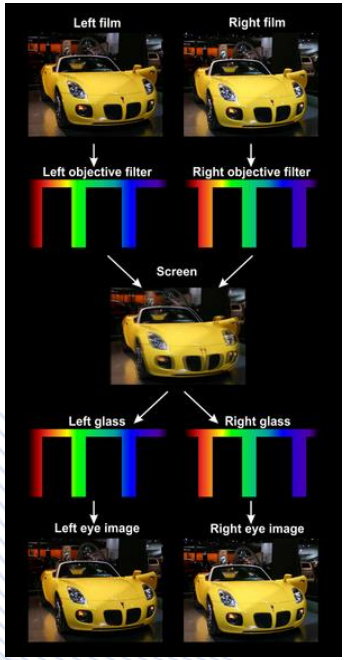
Color-encoded stereo image (anaglyph)

- Depth based on binocular disparity.
- Two images superimposed, offsetted, with complementary hues (e.g. red and cyan).
- The viewer wears glasses, letting a hue pass and blocking its complementary.
- Full color range recreated in human brain.
- Latest example: Colorcode 3D, Dolby 3D.



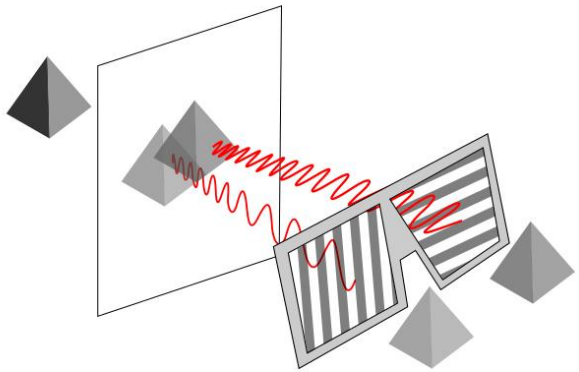
Dolby 3D

- Images for left and right eyes have the same visible color but slightly different wavelengths.
- Glasses with dichroic filters. They selectively let through wavelengths.
- The wavelenghts of the left image reach the left eye, respectively the right one.



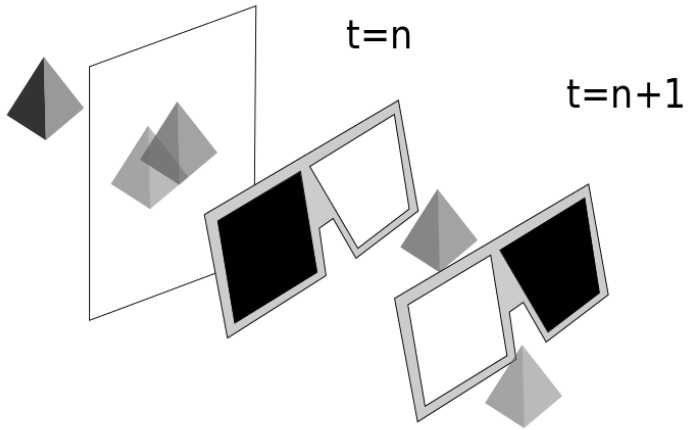
Polarization-encoded stereo image

- Same working principle with anaglyph but different encoding.
- The two images are overlapping but separable by polarization:
  - Linear: Images polarized in orthogonal directions.
  - Circular: Images polarized in circular directions with opposite spin.
- Glasses with polarization filters let through only the image corresponding to each eye.



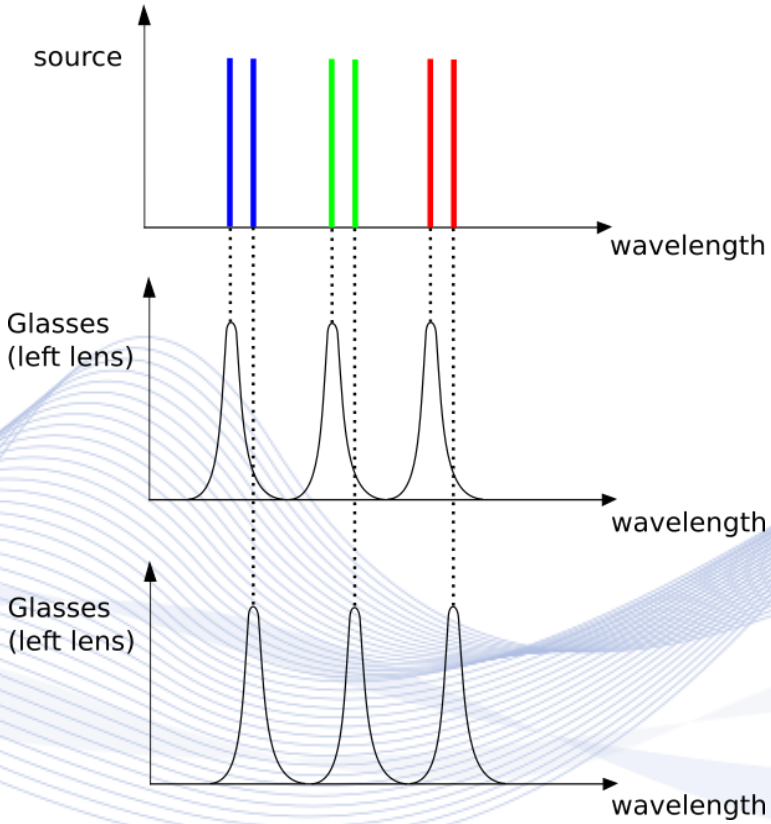
Time-multiplexed stereo image

- Images for the left and right eyes are projected alternately.
- Requires glasses with flipping opacity: When left image is projected the left lens becomes transparent and the right opaque and vice versa.



Wavelength-multiplexed stereo image

- Uses slightly offset spectral ranges for left and right images.
- Glasses with narrowband filters separate the images.
- Left and right image spectral ranges for each color close enough to be perceived as the same color.

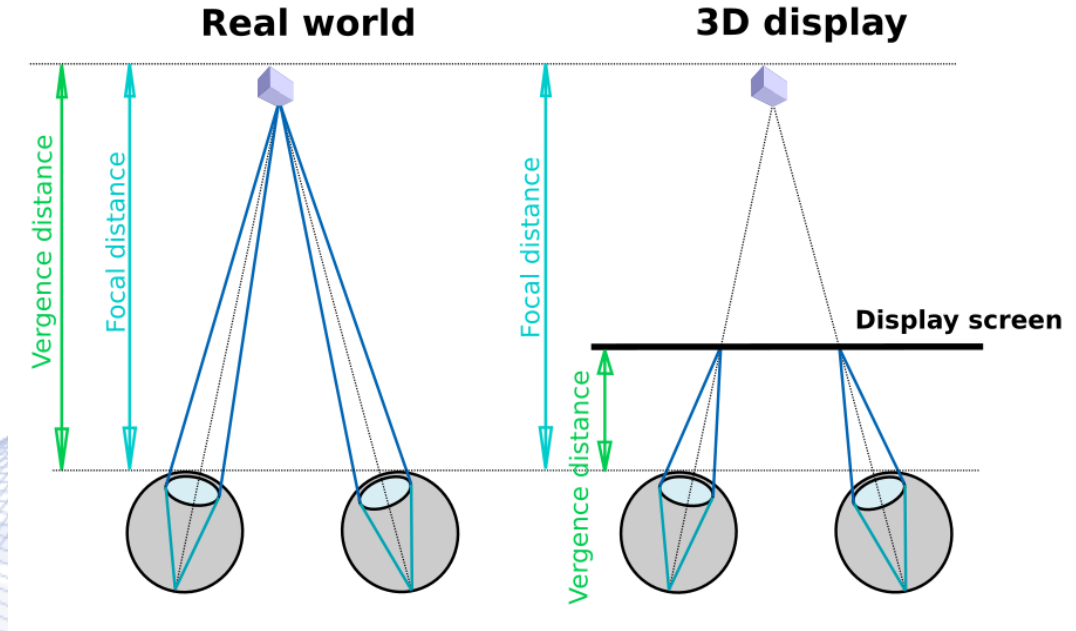


Head-mounted displays

- Head-tracking
- Virtual reality headsets
  - Complete immersion.
  - Examples: Oculus, Vive, etc.
- Augmented reality headsets
  - 3D objects superimposed on real-world view.
  - Examples: Google Glass, MS Hololens.

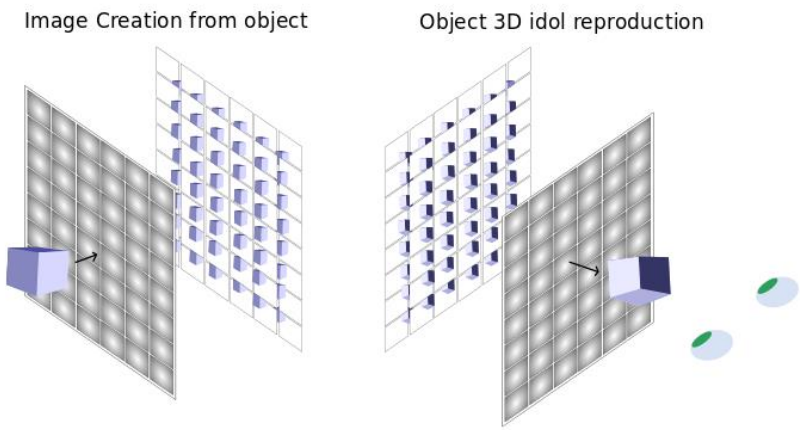
3D Image creation with Accommodative Compansation

- Vergence-accommodation conflict:
  - Mismatch of vergence and focal distances.
  - Causes fatigue and discomfort.
  - Contributes to VR sickness.
- Key technologies to resolve:
  - Gaze-tracking
  - Screen movement



Integral imaging

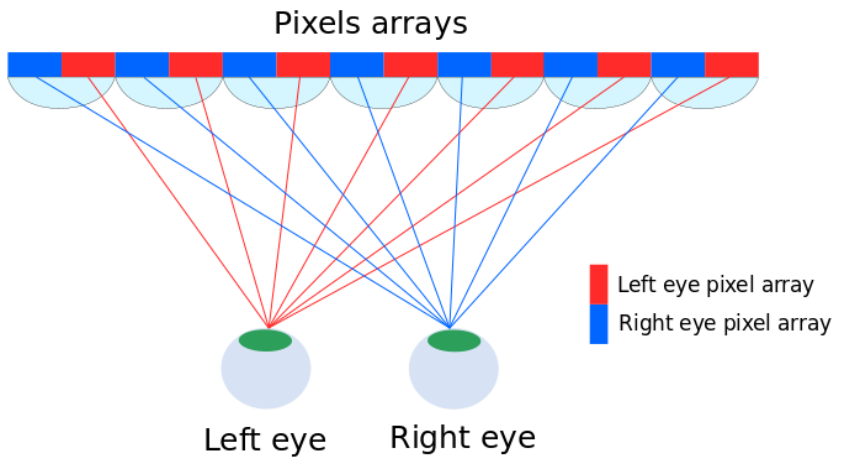
- Image is acquired through an array of microlenses.
- Micro-images from each lens are captured in the storing medium.
- The Micro-images are displayed on flat screen.
- The 3D image is reconstructed after passing through an array of microlenses.
- Suitable for images with horizontal or vertical parallax.
- Problems: Limited viewing angle and depth perception, low resolution, large datasizes.



Lenticular imaging

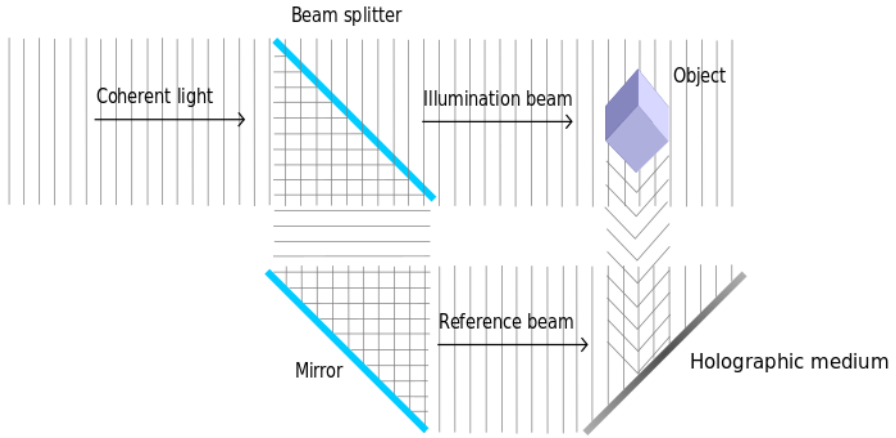
- Lenticular film applied to screen surface.
- Adjecent vertical pixel strips contain the left and right views.
- Each lens of the film interlaces the two views.

- Problems:
  - Vertical resolution reduced by half.
  - Viewer position must be fixed.



Holographic imaging

- Based on the wave-like properties of light.
- Image acquisition:
  - Light reflected by the object to be displayed interferes with a reference light.
  - The interference pattern is recorded on holographic medium.
- Reproduction:
  - By illuminating the holographic medium with the same interference light.

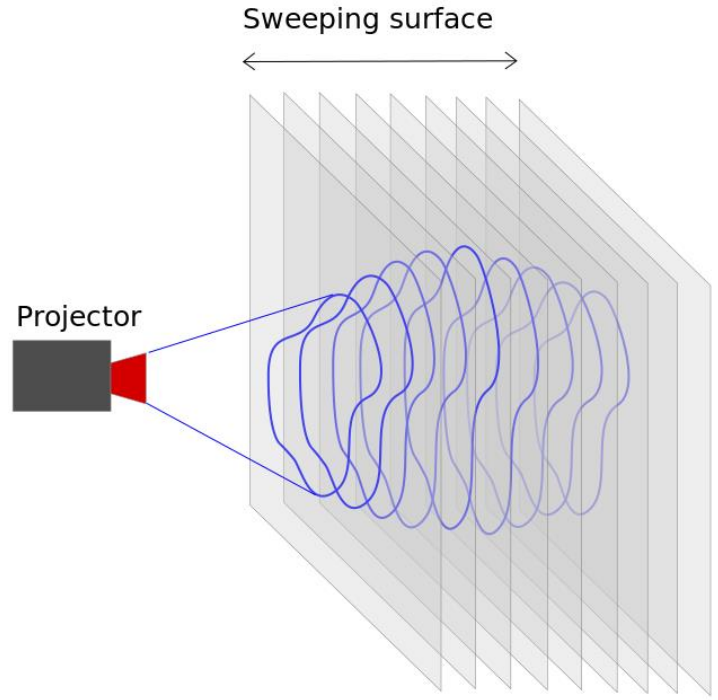


Volumetric displays

- Technologies
  - Swept surface display.
  - Varifocal mirror display.
  - Static volume.
- Advantages
  - No accommodation-convergence conflict.
  - Multiple viewers at the same time.
  - High resolution.

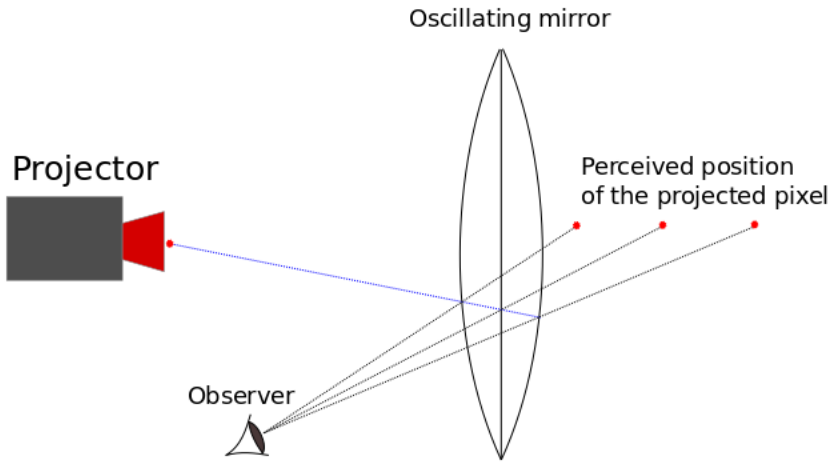
Swept surface display

- Based on persistence of vision.
- An object is sliced in angles that are projected on a moving surface.
- The surface movement is synchronized with the projected angle.



Varifocal mirror display

- A deformable mirror surface is used.
- It oscilates between convex and concave.
- The image captured is sliced by depth.
- Depth-slices are projected on the mirror at the right curvature.

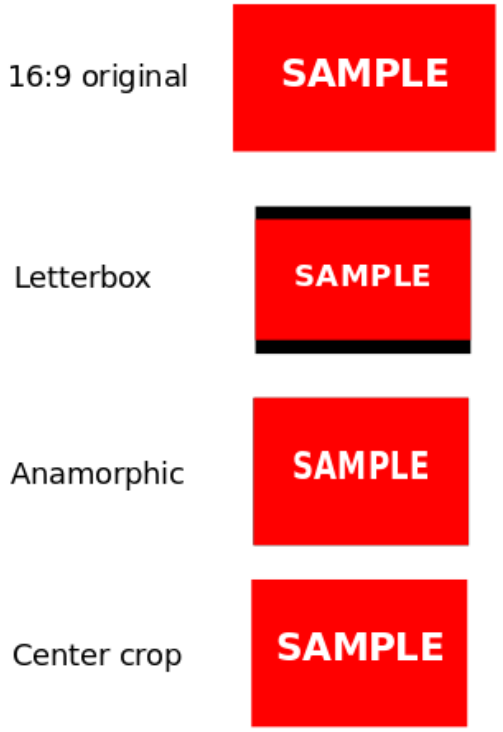


3D image generation and postproccessing

- Layered depth video or Display-independent 3DTV production.
- Real-time 3DTV content analysis.
- 2D to 3D conversion.
- Video reframing.

Video reframing

- Static
  - Pillarboxing
  - Anamorphic video
  - Cropping
  - Pan and Scan
- Dynamic
  - Visual attention model
  - Auto-reframing



Bibliography

[NIK2000] N. Nikolaidis and I. Pitas, 3D Image Processing Algorithms, J. Wiley, 2000.
[PIT2021] I. Pitas, “Computer vision”, Createspace/Amazon, in press.
[PIT2017] I. Pitas, “Digital video processing and analysis ” , China Machine Press, 2017 (in Chinese).
[PIT2013] I. Pitas, “Digital Video and Television ” , Createspace/Amazon, 2013.
[PIT2000] I. Pitas, Digital Image Processing Algorithms and Applications, J. Wiley, 2000.
[SZE2011] R.Szelinski, “ Computer Vision ” , Springer 2011
[DAV2017] Davies, E. Roy. “Computer vision: principles, algorithms, applications, learning ”. Academic Press, 2017
[TRU1998] Trucco E, Verri A. “Introductory techniques for 3-D computer vision”, Prentice Hall, 1998.
[GEO] http://geozone.ch/en/visionlidar-en

Q & A

Thank you very much for your attention!

More material in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

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