Overview of recent 3D display

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OEQE Lab
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Introduction to 3D display

- Cues for depth perception of human
- Various methods to display 3D images
Cues for depth perception of human

- Physiological cues
  - Accommodation
  - Convergence
  - Binocular parallax
  - Motion parallax

- Psychological cues
  - Linear perspective
  - Overlapping (occlusion)
  - Shading and shadow
  - Texture gradient
Introduction to 3D display

- Cues for depth perception of human
- Various methods to display 3D images
### Various methods to display 3D images

<table>
<thead>
<tr>
<th>Classification</th>
<th>Depth cues</th>
<th>Key component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stereoscopy</strong> (requires glasses)</td>
<td>Binocular disparity</td>
<td>Polarizing glasses</td>
</tr>
<tr>
<td><strong>Two-view or Multi-view display</strong></td>
<td>Binocular disparity, Convergence, Motion parallax (horizontal only, limited range, discrete)</td>
<td>LC shutter glasses</td>
</tr>
<tr>
<td><strong>Autostereoscopy</strong> (does not require glasses)</td>
<td></td>
<td>Wavelength selective glasses</td>
</tr>
<tr>
<td><strong>Super multi-view</strong></td>
<td>Binocular disparity, Convergence, Motion parallax (H only, continuous), Accommodation</td>
<td>Parallax barrier</td>
</tr>
<tr>
<td><strong>High density directional display</strong></td>
<td></td>
<td>Lenticular lens</td>
</tr>
<tr>
<td><strong>Integral imaging</strong></td>
<td>Binocular disparity, Convergence, Motion parallax (H&amp;V, continuous), Accommodation</td>
<td>HOE (Holographic Optical Element)</td>
</tr>
<tr>
<td><strong>Volumetric display</strong></td>
<td>Binocular disparity, Convergence, Motion parallax, Accommodation</td>
<td>Directional BLU</td>
</tr>
<tr>
<td><strong>Holographic display</strong></td>
<td>Binocular disparity, Convergence, Motion parallax, Accommodation</td>
<td>Lenticular lens</td>
</tr>
<tr>
<td></td>
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<td>Multiple projection</td>
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<tr>
<td></td>
<td></td>
<td>Laser scanning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lens array (2D)</td>
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<tr>
<td></td>
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<td>Stacked screens</td>
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<tr>
<td></td>
<td></td>
<td>Spinning screen/mirror</td>
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<td></td>
<td></td>
<td>Crossed-beam (Two-photon absorption)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electro-holography (Coherent optics)</td>
</tr>
</tbody>
</table>
Present status of 3D display

- **Stereoscopic display**
- Autostereoscopic display
  - Parallax Barrier
  - Lenticular
  - Integral imaging
  - Volumetric display
  - Holographic display
Stereoscopy

Polarization glasses
Shutter glasses
HMD

Uncomfortable, but easy to commercialize
Polarization multiplexed method

The world's largest ultra high definition 3D home theater

Polarization modulation

→ Luminance decreased
Shutter glasses

The World 1st True 240Hz
55" FHD 240Hz

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Shutter glass

LG 3DTV (Shutter glass)  Samsung Electronics

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HMD using scanning fiber display (Univ. of Washington)

Near-to-eye display using scanning fiber display engine

Image resolution:
500 × 500 (10 bit RGB)
Scan rate:
30 Hz
Horizontal field of view:
100°
Present status of 3D display

- Stereoscopic display
- **Autostereoscopic display**
  - Parallax Barrier
  - Lenticular
  - Integral imaging
  - Volumetric display
  - Holographic display
Autostereoscopic methods

Parallax Barrier

- **Advantages**
  - Multi-view
  - Easy to fabricate

- **Disadvantages**
  - Very low 3D luminance

Lenticular

- **Advantages**
  - High 3D luminance
  - Multi-view

- **Disadvantages**
  - Special 3D/2D conversion technique
  - Harder to fabricate (high cost)
  - Color dispersion

Integral imaging

- **Advantages**
  - Full parallax (both horizontal and vertical)
  - Quasi-continuous view point

- **Disadvantages**
  - Low resolution
  - Limited viewing angle
  - Limited image depth
Parallax barrier: principle

- Binocular type

- Multi-view type

Resolution & Luminance → 50%

Resolution & Luminance → 33%
Lenticular: principle

- Lenticular lens

- Multi-view lenticular
**Lenticular: Samsung Electronics**

Reduced Eye Fatigue
- Auto Stereoscopic -

52"

<table>
<thead>
<tr>
<th>Items</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display size</td>
<td>52 inch</td>
</tr>
<tr>
<td>Resolution (3D only)</td>
<td>640 x 360</td>
</tr>
<tr>
<td>Brightness</td>
<td>cd/m²</td>
</tr>
<tr>
<td>Contrast ratio</td>
<td>2000:1</td>
</tr>
<tr>
<td>3D depth</td>
<td>30 mm</td>
</tr>
<tr>
<td>Viewing distance</td>
<td>3.5 m</td>
</tr>
<tr>
<td>Viewing point</td>
<td>9 view</td>
</tr>
</tbody>
</table>

SID 2010

OEQE LAB @ Seoul National University, Korea
Present status of 3D display

- Stereoscopic display
- Autostereoscopic display
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  - Lenticular
  - Integral imaging
  - Volumetric display
  - Holographic display
**Integral imaging: principle**

- **Pickup**: Forming integral image composed of many elemental images
- **Display**: Retracing the original routes and forming 3D image
Representative methods for enhancement in integral imaging

- Depth enhancement: Dynamically variable image plane, uniaxial crystal plate, optical path control, polarization devices, layered panel integral imaging,
- Viewing angle enhancement: Polarization-multiplexing method, spatial and time multiplexing using polarization state, dynamic barrier method, embossed screen, curved lens array & screen,
- Resolution enhancement: Moving lens array, spatiotemporally multiplexing, high quality using multiple projector, rotating prism sheets

- 2D/3D convertible integral imaging method
- Integral floating display
Present status of 3D display

- Stereoscopic display
- Autostereoscopic display
  - Parallax Barrier
  - Lenticular
  - Integral imaging
  - Volumetric display
  - Holographic display
• Various methods exist.

• Compared to other techniques:
  ○ Advantages
    ▪ Large viewing region
    ▪ Satisfy almost all depth perception cues
  ○ Disadvantages
    ▪ Limited space of expression
    ▪ Hard to achieve occlusion
    ▪ Bulky structure
    ▪ Limited contents
- Images taken from different positions

- Each view of the 3D image comes from multiple modules
- Smooth and continuous transition between views
- Directionally reflective screen
- 24 views from 24 mirrors
- Frame rate: 60Hz

Multi-layered display with water drops

Video

Image

Text

Game

Present status of 3D display

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  - **Holographic display**
Curved SLM array (Seoul National Univ.)

Computer generated holograms and numerical reconstructions

Pictures of the implemented dynamic holographic stereogram

1st view

19th view

36th view
Summary

- High preference to the realistic display: Education, Movie, Entertainment
- Reasonable price in premium market: new trend to 3DTV
- Difficulty of illegal copy of 3D contents

Limitations
- Visual fatigue in viewing stereoscopic display
- Inconvenience of wearing glasses
- Need to improve brightness of 3D image
- Lacking 3D contents