3DTV
based on integral method

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For enjoying 3D television

Spatial imaging
- without special glasses
- laying on a sofa
- during long hours

Television
- with family.
- far objects.

Enjoying 3D television
**Principle of Integral method**

(a) Pickup stage

- Object
- Lens array
- Pickup plate
- Z(-)
- Real object area (R.O. area)

(b) Display stage

- Display plate
- Reproduced image
- Observer
- Z(+)
- Real image (R.I. area)

**Spatial imaging type**

Image’s appearance changes as the viewer’s position moves

- Holography
- Integral Method

Object reconstructed as a spatial image
Gradient index lens (GRIN lens)

\[-\frac{3}{4}L_p\]

GRIN lens

Input light

\[\begin{align*}
0 & \quad \frac{L_p}{4} & \quad \frac{L_p}{2} & \quad \frac{3L_p}{4}
\end{align*}\]

\(L_p\): one period of ray path

Reconstructed images by integral method

(a) Reconstructed spatial 3D image

(b) Projected image on diffuser set 10mm away from lens array.

(c) Projected image on diffuser set 40mm away from lens array.
Integral 3D TV in NHK STRL

Integral TV based on integral photography needs huge number of pixels

- Using HDTV
  - 1996: real-time, monochromatic, pseudoscopic
  - 1997: real-time, full-color, orthoscopic
    - Elemental lenses: 54 (V) X 63 (H), Viewing zone: 20 degree

- Using 2000 scanning lines TV system
  - 2001: real-time, full-color
  - 2004: improved system
    - Elemental lenses: 125 (V) X 160 (H), Viewing zone: 12 degree

- Using 4000 scanning lines TV system
  - 2007: Bayer pixel arrangement. (Dual-G)
    - Number of elemental lenses: 140 (V) X 182 (H)
    - Viewing zone: 24.5 degree (measured value)
  - 2009: Full pixel arrangement
    - Improved resolution

Major resolution factors

- Diameter of elemental lens
  - Small diameter degrades the resolution for distant object because diffraction affects the resolution.
  - Large diameter brings large pitch between adjacent elemental lenses.

- Pitch between adjacent elemental lenses

- Pixel pitch of elemental image

- Viewing zone angle

Dominant in our system
Experimental television system

Dual green UHDTV with 8milion pixel devices

Depth control lens

Converging lens

UHDTV camera (4000 scanning lines)

Projected image

Diffusion screen

Reconstructed image

Object

Virtual object (Optical images)

GRIN lens array

Elemental lenses

125(V) X160(H)

- Developed with Victor Company of Japan
- Supported by National Institute of Communications Technologies
Elemental lenses alignment of lens array

\[ P_{da} = 42.5 \text{ pixels} \]

\[ P_{dh} = \frac{42.5}{2} \]

\[ 42.5 \times \frac{\sqrt{2}}{2} = P_{dv} \]

Resolution characteristics

- Maximum visual-spatial frequency -

Nyquist frequencies:
- sampling by lenses
- sampling by pixels

Calculated value

\[ \hat{\beta}_{SL} = \hat{\beta}_{SL}/758 \text{ cpr} \]

\[ \hat{\beta}_{SL} = 1/\sqrt{3} \]

Object position (m)

(Real object side)  (Observer side)

\[ D = 2.51 \text{mm}, P_{da} = 2.64 \text{mm} \]
\[ g_d = 5.41, l_{cap} = 2.0 \text{ m} \]
Reconstructed images with full parallax

Object: Real doll

(a) Upper viewpoint
(b) Lower viewpoint
(c) Left viewpoint
(d) Right Viewpoint

Pixel structure of Dual-G system

Each pixel has R or G or B signal. G1 and G2 pixel are diagonally offset.

Each pixel has R, G, and B signal.

\[ \bigcirc = \bullet + \textcolor{green}{\circ} + \textcolor{blue}{\blacksquare} \]
Experimental television system

Full pixel UHDTV with 33 million pixels

Depth control lens

Converging lens

Diffusion screen

Reconstructed image

Object

Virtual object (Optical images)

GRIN lens array

160(H) x 125(V) lenses

UHDTV camera (4000 scanning lines)

UHDTV projector (4000 scanning lines)

R,G,B

Lenses array

Summary

- The 3D TV with integral method is based on extremely high resolution video.

- The experimental setup produces full-color and full-parallax 3D images in real-time, however, the setup has not reached practical level yet.

- To produce higher quality 3D images for television, it requires a larger number of pixels for the capture and display stages. Although this problem must be overcome, our experimental setup has been progressed one step for practical use.