Characterizations of 3D TV: Active vs Passive

Börje Andrén, Kun Wang, Kjell Brunnström

\(^a\) NetLab: IPTV, Video and Display Quality, Acreo AB, 16440 Kista, Sweden

\(^b\) Dept. of Information Technology and Media, Mid Sweden University (MIUN), 85170 Sundsvall, Sweden
Introduction

• Compare active vs passive
  • Two 55 inch 3D TV: one active shutter glasses and one passive frame pattern pattern retarder (FPR)
• TCO 3D TV methods and requirements
• Involvement in ICDM
• Tested parameters
  • Angular dependent Crosstalk
  • Resolution
  • Flicker visibility
  • Luminance
  • Colour
Basic test set-up

Measurement device
PR-705, Dalsa/Canon camera

Active shutter / passive polarized glasses

3D display

vertical ±30°

horizontal ±30°

Flicker detector
Angular dependent crosstalk measurement

Background

• Test crosstalk horizontal and vertical angle.
• Tests influence of test image design
• Two different test patterns (side-by-side)
  • A full screen (left) and B on 128 grey (right).
• B turns dynamic backlight off
• B closer to real imagery on average grey level
Angular dependent crosstalk measurement

Method

- NVIDIA 3D vision
- PhotoResearch 705 spectroradiometer
- Crosstalk calculated using:

\[
\text{Crosstalk(\%)} = 100 \cdot \frac{L_{bw} - L_{bb}}{L_{wb} - L_{bb}}
\]
Angular dependent crosstalk measurement

Results

Crosstalk vs horizontal angle

Angle in degrees

Active bg128 hor  Active full screen hor
Passive bg128 hor  Passive Full screen hor
Angular dependent crosstalk measurement

Results

Crosstalk vs vertical angle

Angle in degrees

- Active bg128 vert
- Active full screen vert
- Passive bg128 vert
- Passive Full screen vert
Angular dependent crosstalk measurement

Conclusions

• Passive
  • More sensitive for **vertical** positioning
  • Crosstalk increase rapidly > 10 degrees (vertical)

• Active
  • Some sensitivity to test pattern
  • Still quite low crosstalk
  • May be influence of dynamic backlight

• $L_{bb}$ usually very **small** minor influence
Resolution test
Test target

- 3 columns (A, B and C)
- 6 groups in vertical direction of bar patterns (1 to 6)
- The B column is shifted 1 vertical pixel line down from the A column
- A and B for vertical resolution and C column is for horizontal
- The 6 groups contain 3-bars with a bar thickness of 1 pixel line (group 1) to 6 pixel lines (group 6)
Resolution test
Active shutter-glass 3D TV

(a) 3D Without Eye-glass
(b) Though left eye-glass
(c) Though right eye-glass

For Left view
For Right view

Line Space

All 6 groups of bars in the vertical test pattern are shown correctly for all columns (A & B)
Resolution test
Passive FPR 3D TV

Passive FPR 3D TV in 2D-mode
Resolution test
Passive 3D TV

Group 1: Able to reproduced
Group 2: Not able to reproduce. Affects by one pixel shifts
Group 3: Not able to reproduce. Affects by one pixel shifts
Resolution test
Intensity distribution on passive 3D TV

1 bar target
2 bar target
3 bar target
Flicker visibility
Background

• Test if we can expect flicker from 3DTV
• To get an idea about the levels to expect
• To evaluate the ICDM procedure
• To evaluate methods for the TCO 3DTV and find suitable requirement
• To see how much the eye-glasses could influence the results
Flicker visibility
Method

- Computer controlled oscilloscope (PicoScope 3204)
- Hagner $V(\lambda)$ corrected detector SD3 Extra sensitive
- Amplifier is made by Acreo
- Measurements with and without eye-glasses
Flicker visibility
Results

Active 3D TV

- At 0 Hz the relative intensity is 100%
- The relative intensity is 70% at 60 Hz
- At about 22 Hz the intensity is 25%
- At about 39 Hz the intensity is 17%
- The Passive 3D TV has no problem
\[ I_{\text{flicker}} = TCSF(R) \times C_R \]
\[ C_R = 2 \times \left| \frac{K_{Nf}}{K_0} \right| \]

- In this example, for the active 3DTV the \( C_R \) is \( 2 \times 0.25 = 0.5 \) for the peak at about 22Hz.
- The \( TCSF \) is about 63 at 22Hz giving a Flicker visibility \( J_{\text{flicker}} \) of about 31 jnd.
- The peaks of about 39 Hz and at 60 Hz give only about 1 jnd due to the TCSF is so low.
Flicker visibility
Discussion

• Flicker problem for active not for passive.
  • 22 Hz flicker observed on other active 3DTVs - intensities varies
  • The 22 Hz flicker is not due to eye-glasses and is present at all 3D modes and inputs
  • Influence of eye-glasses is very small

• Flicker visibility evaluation
  • Furthermore, more research is needed to see the influence of real images and videos
  • Many more test subjects are needed. In the studies performed so far too few have been used (Barten 1999; De Lange, 1956).
Luminance measurement

- Luminance 2D mode (without glasses): both types about 300 cd/ m²

- Passive type transmittence 54%; active type 18%

- Passive luminance angular fall-off 1.6:1 (horizontal 0-30°), 1.3:1 (vertical 0-15°)

- Active type has better angular characteristic, but lower transmitted luminance
**Colour measurement**

**Colour characteristics expressed in CIE 1976 u’v’-values**

### Passive 3DTV angular colour

<table>
<thead>
<tr>
<th>Angle (°)</th>
<th>Vertical u’</th>
<th>Vertical v’</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>-25</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>-20</td>
<td>0.5</td>
<td>0.4</td>
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<td>-15</td>
<td>0.5</td>
<td>0.4</td>
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<tr>
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<tr>
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<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
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<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
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<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>25</td>
<td>0.5</td>
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</tr>
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<td>0.5</td>
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</tr>
</tbody>
</table>

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<td>0.4</td>
</tr>
<tr>
<td>30</td>
<td>0.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Colour temperature (K)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Passive</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D mode</td>
<td>7500-8500</td>
<td>8000-8500</td>
</tr>
<tr>
<td>3D mode</td>
<td>7500-8500</td>
<td>11500</td>
</tr>
</tbody>
</table>

### MireK shift (10e6/CCT)

<table>
<thead>
<tr>
<th>Shift</th>
<th>Passive</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td></td>
<td>38</td>
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</tbody>
</table>

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General conclusions

• **Angle dependent crosstalk**
  - Passive problems vertically
  - Test pattern influenced active horizontal crosstalk

• **Resolution**
  - Active no resolution reduction
  - Passive shows problems reproducing a number of small scale patterns
  - Comes from subsampling step

• **Flicker**
  - Active shows disturbing flicker at 22 Hz
  - Passive show no flicker

• **Luminance**
  - Active less angular dependence, but lower absolute transmittance
  - Passive more angular dependence, but higher absolute transmittance

• **Colour**
  - No angular dependence
  - Active glasses has an influence on colour temperature
SID ’12 OLED Breakthrough

55” FHD OLED [FPR 3D]
Comparison of Simultaneous Measurement of Lens Accommodation and Convergence in Natural Vision and 3D Vision
Tomoki Shiomi et al
University of Fukui, Nagoya Bunri University, Kobe Women's University, Aichi Gakuin University, Fukuyama City University, Japan
Effective Spatial Resolution of Temporally and Spatially Interlaced Stereo 3D Televisions
Joohwan S. Kim, Martin S. Banks
Vision Science Program, University of California, Berkeley
Finally we would like to thank our sponsor: VINNOVA (The Swedish Governmental Agency for Innovation Systems), TCO Development and Intertek Semko

Thank you
Resolution test
Results

• The left view B1 bar target has 3 groups and the correct number of bars, but the intensity is about \( \frac{1}{4} \) of B2
• The left view B2 bar target has 3 groups and correct intensity, but the bars are \( \frac{1}{2} \) width
• The left view B3 bar target has 3 groups, but the groups consist of 2 bars instead of 3, with 1 bar with 1/4 intensity, 1 bar with full intensity and 1 bar is missing
Angular dependent crosstalk measurement
Results continue

### Active

<table>
<thead>
<tr>
<th>Degrees</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction</td>
<td>hor</td>
<td>hor</td>
<td>hor</td>
<td>hor</td>
<td>hor</td>
<td>hor</td>
<td>hor</td>
</tr>
<tr>
<td>Active bg128</td>
<td>0.76%</td>
<td>0.73%</td>
<td>0.95%</td>
<td>1.38%</td>
<td>1.96%</td>
<td>2.86%</td>
<td>3.69%</td>
</tr>
<tr>
<td>Active Full screen</td>
<td>0.30%</td>
<td>0.31%</td>
<td>0.32%</td>
<td>0.34%</td>
<td>0.37%</td>
<td>0.41%</td>
<td>0.45%</td>
</tr>
<tr>
<td>Passive bg128</td>
<td>0.59%</td>
<td>0.60%</td>
<td>0.55%</td>
<td>0.48%</td>
<td>0.40%</td>
<td>0.34%</td>
<td>0.33%</td>
</tr>
<tr>
<td>Passive Full screen</td>
<td>0.93%</td>
<td>0.97%</td>
<td>0.88%</td>
<td>0.76%</td>
<td>0.63%</td>
<td>0.50%</td>
<td>0.43%</td>
</tr>
</tbody>
</table>

### Passive

<table>
<thead>
<tr>
<th>Degrees</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction</td>
<td>vert</td>
<td>vert</td>
<td>vert</td>
<td>vert</td>
<td>vert</td>
<td>vert</td>
<td>vert</td>
</tr>
<tr>
<td>Active bg128</td>
<td>0.76%</td>
<td>0.82%</td>
<td>1.21%</td>
<td>1.73%</td>
<td>2.58%</td>
<td>3.42%</td>
<td>4.43%</td>
</tr>
<tr>
<td>Active Full screen</td>
<td>0.93%</td>
<td>0.93%</td>
<td>1.25%</td>
<td>1.80%</td>
<td>2.52%</td>
<td>3.41%</td>
<td>4.48%</td>
</tr>
<tr>
<td>Passive bg128</td>
<td>0.59%</td>
<td>0.73%</td>
<td>1.22%</td>
<td>9.98%</td>
<td>28.07%</td>
<td>54.54%</td>
<td>90.75%</td>
</tr>
<tr>
<td>Passive Full screen</td>
<td>0.93%</td>
<td>0.99%</td>
<td>1.46%</td>
<td>8.33%</td>
<td>24.35%</td>
<td>47.24%</td>
<td>80.37%</td>
</tr>
</tbody>
</table>
Bar test patterns displayed in Passive FPR 3D TV (temporal interpolation function on)

(a) 3D Without eye-glass
(b) Though left eye-glass
(c) Though right eye-glass
• The 3D luminance is lower for the active eye-glasses 3DTV due to denser eye-glasses at the same 2D luminance than for the FPR

• The adaptation of the human visual system compensate for this but not to 100%.

• The angular luminance is less uniform for the FPR 3DTV than for the active 3DTV, but it is hard to see if you do not move horizontally or vertically.

• Surrounding objects like playing children will be harder to see if the eye-glasses are too dark in home environments.