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MUSCADE Focus

Quarterly newsletter of the MUSCADE consortium

Volume 3, Issue 1 JAN-MAR 2012

Special points of interest:

- The position statement is on User tests on the visual comfort of various 3D display technologies
- MUSCADE Partners won "MPEG Call for Proposals on 3D Video Coding Technology"

Inside this issue:

User tests on the visual comfort of various 3D display technologies

Position Statement submitted by Emad Kovacs Peter Tamas of Holografika

Visual comfort consists of several factors related to the convenience of viewing the 3D content on the screen. These factors include necessity of viewing equipment, restrictions in freedom of choosing viewing position, head movements and head orientation, safety and health issues, and suitability for long-term use. Importance of these factors might not be immediately apparent when evaluating visual quality in controlled environment artificially setup for short subjective testing sessions However, it definitely affect the acceptance of 3D visualization techniques in a home environment for everyday use. In order to learn about what people really think and feel about comfort when using 3D displays, an extensive user test was conducted using three 3D displays types with different technology for displaying 3D images.

Bonsai

Shoe

MUSCADE Band06

Ivy

Figure 1. Some representative examples from the contents

Test setup, content, volunteers, and the questionnaire

Following displays have been used in the experiment:

A stereoscopic display - 55" full HD micropolarizer-based passive stereoscopic display.

An autostereoscopic display - 47" full HD lenticular-lens based 8-view display.

Light-field display - 72" HoloVizio light-field display.

We have prepared the same content playlist for all

Continued on page 2...

User tests on the visual comfort of various 3D display technologies

continued...

three displays, including the MUSCADE Band06 sequence. The playlists have been repeated on each display simultaneously, with no audio for any of the three displays. Some representative examples from the contents shown in Figure 1.

The user tests were organized as an open one-day event, anybody who was interested to see 3 different 3D displays side-by-side could participate. We provided them with basic instructions about the different displays. They were allowed to stand, walk or sit down on the chairs provided, talk to each other or us, ask questions, and provide oral feedback. Multiple viewers were allowed to be in the room at the same time, if they wished to do so.

We welcomed 33 volunteers during the day (25 male and 8 female) who were mostly non-expert viewers. Their age ranged from 17 to 74 years. Approximately half of the viewers wore glasses, and none of them reported previous difficulties with stereoscopic vision. The majority of the viewers (85%) have seen at least one 3D movie previously, 85% in cinema, 33% on a computer, 18% on TV. Interestingly, none of the 33 viewers reported seeing 3D on a mobile device before, even though this has been one of the options in the form. All of them used glasses for their previous 3D experience. On average they rated their previous 3D experience 3.69 (1 meaning very bad and 5 being the best).

The questionnaire contained general questions about the viewer, some questions related to the quality of 3D videos, and most importantly, questions related to visual comfort.

General questions

Gender, Age, Highest education

- Do you wear glasses?
- Do you have any difficulty with spatial vision?
- Have you seen a 3D movie before?
- If yes, where? (mark all that apply) Cinema/TV/Computer/Mobile device /Other
- Did you use glasses for that?
- How would you judge your previous 3D experience? (1: very bad .. 5: very good)
- If you rated below 3, please justify

Questions related to the quality of 3D videos and images

Please judge all three displays one by one for each question (1: very bad .. 5: very good).

- Image quality (colours, brightness, etc.)
- Depth quality, spatial reconstruction
- Naturalness, lifelike image (distortion, ghost image, etc.)
- Image stability (jumps, following image, etc.)
- Could you inspect and look around the 3D content? Did you experience any distortions?
- How real did the content look (tangible realistic scenes or shiny, transparent look)?
- Overall 3D impression

Questions related to visual comfort

Please judge all three displays one by one for each question.

- Did you experience any eye strain or visual fatigue? Was it difficult to grasp the 3D content? (1: very bad .. 5: did not experience this)
- Headache, nausea or sea sickness (1: very bad .. 5: did not experience this)
- Disturbing, unnatural, or inaccurate depth effects (1: very bad .. 5: did not experience this)

"The most important individual factors having serious impact on viewing comfort are eye fatigue and the necessity of wearing glasses. The light-field display outperformed the stereoscopic and multiview display in all visual comfort related factors."

Continued on page 3...

Volume 3, Issue 1

User tests on the visual comfort of various 3D display technologies

continued...

- If you had to wear glasses, did you find it convenient? (1: very inconvenient .. 5: very convenient) – just for the stereoscopic display
- If it was inconvenient, why? (free text)
- Did you try to move while watching? If so, did you feel the 3D perspective natural during / after movements? (1: something was wrong .. 5: completely natural)
- Did you try to move or tilt your head while watching? If so, did the 3D experience disappear or distort during or after these movements? (1: something was wrong .. 5: completely natural)
- Did you experience any other artefact or disturbing effect not mentioned in this questionnaire? (free text for all three displays)
- If more of you have been watching simultaneously, did other viewers disturb you while finding your viewing spot? (Yes / no for all three displays)
- How long could you watch 3D videos on these displays? (free text for all three displays)
- Overall impression about visual comfort (1: very uncomfortable .. 5: very comfortable)

Average scores for factors affecting 3D image quality

The average values for the stereoscopic display and the multiview display in all aspects are between 3 and 4 for the stereoscopic display, while the multiview display scored below 3 in some aspects. The light field display scored over 4 in all aspects, and consistently scored higher than the other two.

We have seen a small positive correlation between the scores given for previous 3D experiences and the scores given for image quality (0.35), depth quality (0.25), distortion (0.38) and realism (0.33) aspects in case of the multiview display. We have also seen a small positive correlation between the scores given for image stability (0.33) and the realism (0.30) versus the score of the previous 3D experience.

Our conclusion from these correlations is that people who judged their previous experiences with 3D stricter, also judged these displays more critically, especially the multiview display.

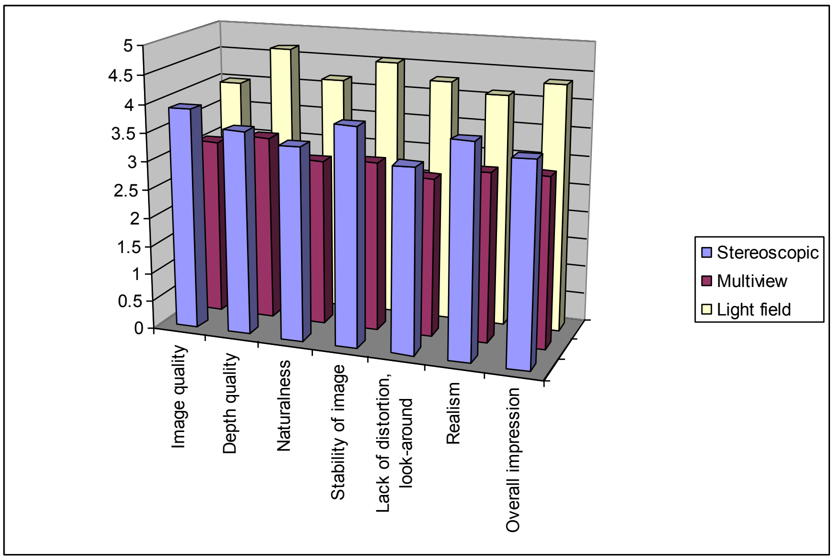

Figure 2. Average scores for factors affecting 3D image quality

Average scores for factors affecting visual comfort

The average values given for the factors affecting visual comfort averaged around 3.3 for the stereoscopic display, and below 3 for the multiview. The light-field display received higher scores in every aspect, and scored above 4 in total.

The strongest correlation we have found between the comfort factors and the overall comfort score for the given display is Eye fatigue in case of the multiview display (0.76), and the comfort of wearing glasses in case of the stereoscopic display. The factor that correlates most with the

Continued on page 4...

User tests on the visual comfort of various 3D display technologies

continued...

overall comfort score in case of the light field display was the image stability during head movements (0.54).

From the average of correlation values given for all 3 displays, it turns out that eye fatigue (0.56) and the comfort of wearing glasses (0.58) are the ones that mostly affect the overall comfort score (the latter affecting only stereoscopic displays of course).

The average values given for the factors affecting visual comfort averaged around 3.3 for the stereoscopic display, and below 3 for the multiview. The light-field display received higher scores in every aspect, and scored above 4 in total.

The strongest correlation we have found between the comfort factors and the overall comfort score for the given display is Eye fatigue in case of the multiview display (0.76), and the comfort of wearing glasses in case of the stereoscopic display.

The factor that correlates most with the overall comfort score in case of the light field display was the image stability during head movements (0.54).

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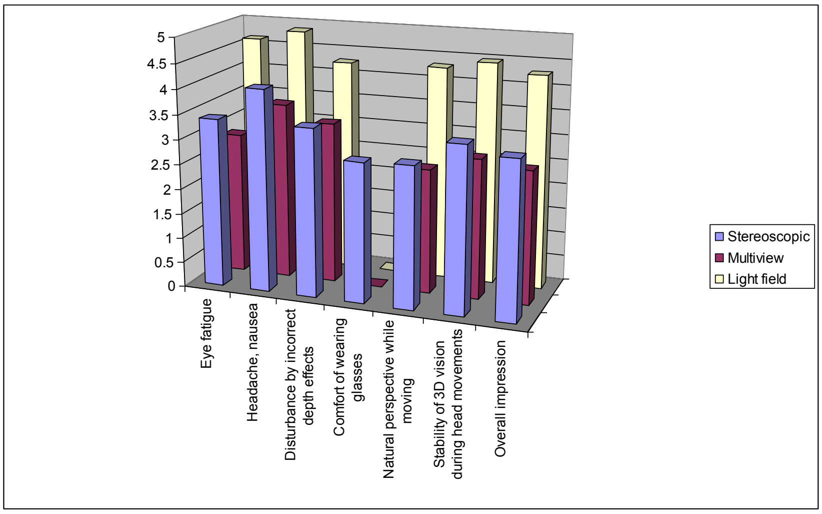

Figure 3. Average scores for factors affecting visual comfort

Textual and oral feedback received

We have asked if they felt the glasses uncomfortable, and if so, why? (free text) The reasons that appeared most frequently are:

- Not wearing glasses, so it feels unusual, or dislike wearing them (34%)
- These glasses are not comfortable to wear, problem with ergonomics (34%)
- Wearing glasses over ordinary glasses is disturbing (27%)
- Loss of light, everything looks darker in glasses (12%)
- Impractical, and disturbs when looking somewhere else, not the TV (12%)
- Constraints of field of vision, does not cover the whole viewing range (8%)

We have also asked if they perceived any other artefacts causing discomfort not mentioned in the questionnaire (free text for each display).

For the stereoscopic display, the most frequently occurring complaints are:

- Depth perception problem, partial depth perception (15%)
- Glasses (9%)
- Incorrect image during movements (6%)
- Dizziness (3%)
- Low brightness (3%)

For the multiview display, the most common complaints are:

- Difficult to find and / or maintain correct viewing position (15%)
- Diagonal stripes on the image (12%)
- Ghost image (9%)
- Flickering (9%)
- Image is jumping during movements (6%)
- Too low resolution (3%)

For the light-field display, the

Continued on page 5...

User tests on the visual comfort of various 3D display technologies

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	Stereoscopic	Multiview	Light-field
Yes	9	17	5
No	19	10	22

Figure 4. "Did other viewers disturb you while finding the correct viewing position?"

most common complaints are:

- Narrow field of view, image darkens / disappears outside viewing range (9%)
- Errors in content (6%)
- Blurry image (6%)
- Reflections on the screen (6%)
- Vertical stripes in the image (3%)
- Too big (3%)

From the 33 viewers, 27 answered the question "Did other viewers disturb you while finding the correct viewing position?"

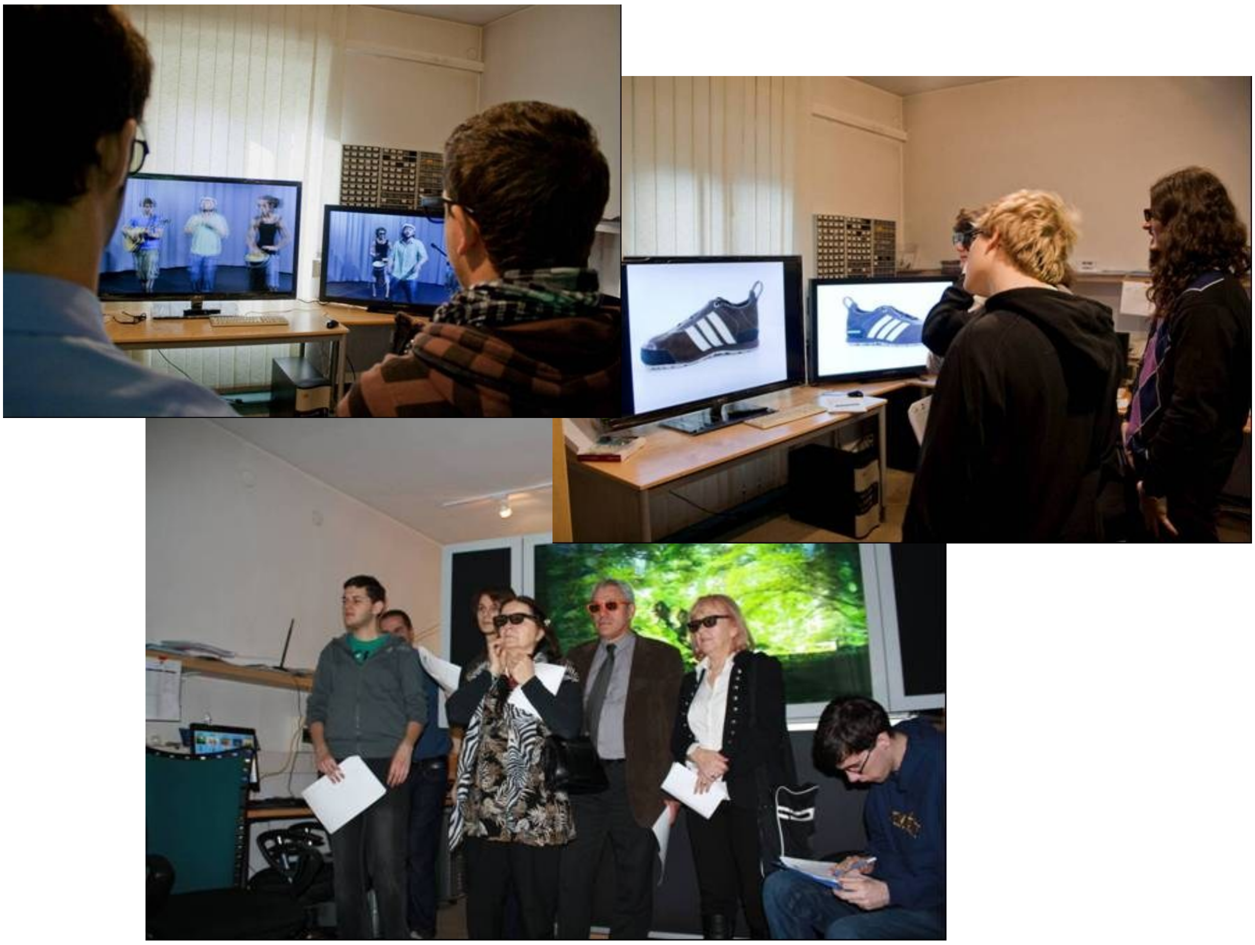
Conclusions

From these results, the main conclusions we have drawn are the following:

Average viewers are less satisfied with the performance of the HD-panel based multiview autostereoscopic display than the glasses-based stereoscopic display, and even the advantage of being glasses-free cannot outweight this.

The most important individual factors having serious impact on viewing comfort are eye fatigue and the necessity of wearing glasses.

The light-field display outperformed the stereoscopic and multiview display in all visual comfort related factors.



MUSCADE Partners won "MPEG Call for Proposals on 3D Video Coding Technology"

End of 2011 MPEG has organized formal and independent subjective tests in context of the "MPEG Call for Proposals on 3D Video Coding Technology". 4 out of 11 proposals were rated best with a subjectively better performance than the others over all bit rates and test sequences. Three of these four winners have been submitted by MUSCADE partner Fraunhofer HHI (see blue, green and red dots in Fig. 1), one of them in collaboration with MUSCADE partner Disney Research Zurich (see blue dot HHI+DRZ) and have been rated as the three best overall proposals.

The main reason for submitting three proposals was to demonstrate that different functionalities which might be important for a successful introduction of future 3D-TV services can be supported with high quality by one common coding framework. These were in particular:

- **Transmission of stereo content without depth maps (HHI+DRZ):** This scenario considers the case where no depth maps are available from the production side or additional depth maps can or shall knowingly not be transmitted in the given transmission or coding framework. Hence, the adaptation of the transmitted stereo content to auto-stereoscopic multi-view displays has to be done entirely at the receiver side. The image domain warping developed by Disney Research Zurich has been used for this receiver-side view adaptation, whereas efficient stereo and multi-view coding has been provided by Fraunhofer HHI.
- **Transmission of stereo content with associated depth maps (HHI1, HHI2):** The stereo content is coded jointly with associated dense pixel-by-pixel depth maps, one for each stereo view. After decoding, the additionally transmitted depth maps can be used to ease the adaptation of stereo content to auto-stereoscopic multi-view displays. Only depth-image based rendering has to be carried out at receiver side, the more complex part of depth analysis can be done at production side. The main difference between the two versions HHI1 and HHI2 are different inter-view prediction and coding modes such that one version provides better quality if the stereo images are decoded independently of the transmitted depth data and, hence, is more suitable for backwards compatible to standard stereo reception.

"Following the above results, it will be possible to provide a new MPEG standard with a wide range of functionality supporting both, efficient 3D video coding with and without depth."

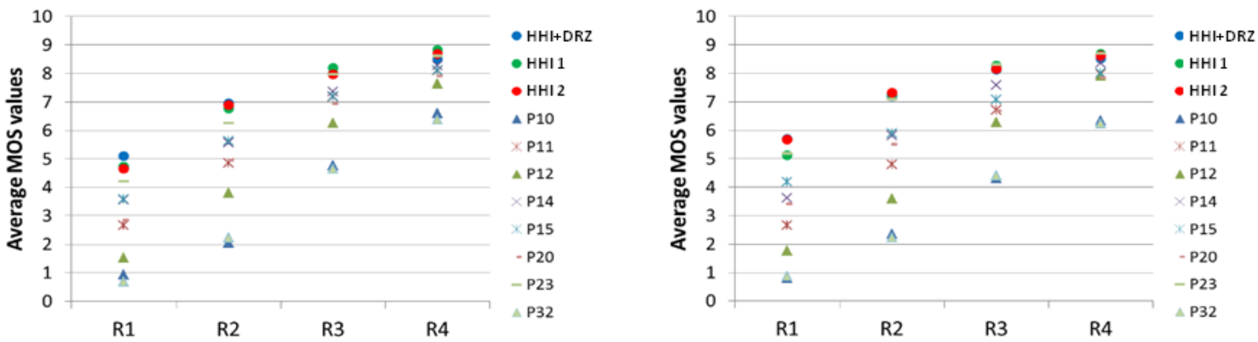


Figure 1. Average results of subjective tests from MPEG evaluation of submitted proposals for two different test conditions using 2 (left) and 3 (right) views

Continued on page 7...

MUSCADE Partners won "MPEG Call for Proposals on 3D Video Coding Technology"

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By now, these results can be interpreted as follows:

- Adaptation of stereo to multi-view at the receiver without using additionally transmitted depth maps provides adequate quality, at least within the application range that has been tested by MPEG. Within this range, it performs equally well as the depth-based approaches without loss of quality. As proven by the MPEG tests, image domain warping from Disney Research Zurich is one highly suitable approach for the adaptation process at the receiver. Another might be the low-complexity real-time L-HRM depth estimator recently developed by Fraunhofer HHI within MUSCADE. Both, are able to convert stereo automatically to multi-view with limited complexity and in real-time.
- The transmission of additional depth maps can be achieved without loss of coding performance, even in case of existing backwards compatibility with depth-independent video decoding. The additional depth data can be coded very efficiently and can even be used for a more efficient coding of the stereo images. Hence, depth maps can be transmitted without further transmission costs wherever it is desired from quality point of view. Basically, reliable adaptation from stereo to multi-view with controlled quality can only be achieved by a supervised process where the depth maps are generated at the production side (either in the OB van or during post-production). Furthermore, generation of depth maps at the production side might provide higher 3D quality due to more computing power and more sophisticated conversion capabilities.

Further tests and evaluations in MPEG will lead to a corresponding standard in 2-3 years. MUSCADE technology will help to go this way. Following the above results, it will be possible to provide a new MPEG standard with a wide range of functionality supporting both, efficient 3D video coding with and without depth. In the sense of the MUSCADE project, this standard will also be able to support a wide range of 3D displays from standard stereo via auto-stereoscopy to future light-field displays.

Submitted by: HHI/DRZ

Publications Corner

Coding of Warps for IDW-based View Synthesis in 3DV Applications

Authors: N. Stefanoski, A. Smolic

Affiliation: Disney Research Zurich

Publication: IISO/IEC JTC1/SC29/WG11, Doc. M23558, San Jose, USA, February 2012

Abstract: In this document, we propose a modification of a transmission and view synthesis system, in which Multi-view Video (MV) is used as transmission format and view synthesis is performed completely automatically at the decoder side using an Image-domain Warping approach. We propose to shift the warp calculation part of the synthesizer to the encoder side, compute warps at the encoder side, and encode and transmit this warps to the decoder side. The proposed modification, leads to a significant reduction of the complexity at the decoder side and leads to an increase of the view synthesis speed up to a factor of 8.7. The modification requires an efficient coding and transmission of warps, which are automatically calculated from the MV data at the encoder side. For this reason, we developed an efficient warp coding method which is presented in this document. We found that compressed warps represent a practically negligible portion of about 3.7% on average of the overall (video+warp) bit rate.

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