From a Different Point of View

How the Field of View of Light Field Displays affects the Willingness to Pay and to Use

Peter A. Kara[1], Peter T. Kovacs[2, 3], Maria G. Martini[1], Attila Barsi[3], Kristof Lackner[3], Tibor Balogh[3]
[1]Wireless Multimedia and Networking Research Group, Kingston University, London, UK, {p.kara, m.martini}@kingston.ac.uk
[2]Holografika, Budapest, Hungary, {p.kovacs, a.barsi, k.lackner, t.balogh}@holografika.com
[3]Department of Signal Processing, Tampere University of Technology, Tampere, Finland, peter.t.kovacs@tut.fi

***Abstract*—Traditional 2D displays can be viewed from any direction, however, the content does not change based on the viewing angle. Light field displays enable the visualization of content from different perspectives, unlike multiview displays, where the actual field of view is narrow and the views are repeated in the viewing zones. In this paper we present the results of a subjective assessment of field of view for light field displays, completed by 20 test participants. Apart from the general subjective evaluation of the different field of views, ranging from 15 to 180 degrees, factors regarding display usage and purchase are addressed as well in this study.**

Keywords—Field of View, Quality of Experience, Light Field Display, Willingness to Pay

I. Introduction

The viewing angle has been used to characterize 2D displays in terms of where the image is visible from, but in this case the image visible is the same from all angles, apart from decreasing brightness or distorted colors in most cases. As such, the quality of images displayed on 2D displays does not fundamentally depend on the viewing angle. However, in case of autostereoscopic 3D displays like Light Field Displays (LFD), the viewing angle is an important quality factor, as it shows from what angles we can expect to see the visualized scene. If a display provides a narrow Field of View (FOV), viewers will observe a diminishing or distorted image while moving away from the viewing zone, which is against the expectations of most viewers, who are used to 2D displays that provide a FOV close to 180 degrees.

In this paper, we analyze the subjective perception of different FOV sizes (angles) for LFDs. Beyond the subjective rating of Quality of Experience (QoE), we take into consideration the test participants' desire to use such displays and also the Willingness to Pay (WTP or W2P); would an individual use an LFD with a given field of view, and would he or she make a financial investment of any extent to own a display with such capabilities?

The paper is structured as follows: Section II introduces relevant related work in the research area. Section III provides the details of the research measurement configuration, followed by Section IV introducing the results, concluded by Section V with the summary of the main findings and possible extensions of the research work.

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II. Related Work

The Information Display Measurements Standard (IDMS) [1] produced by the International Committee for Display Metrology (ICDM) provides information on how to measure the valid viewing area of autostereoscopic displays, such as LFDs or multiview ones, and determines viewing freedom. In previous works [2], closely examining the perceptual effect of a display's FOV has been mentioned as crucial future work. In the paper of Bowman et al. [3], displays are described as an important component of 3D user interfaces, and FOV is listed as an essential characteristic to consider. Apart from FOV, spatial, angular and depth resolution are also vital parameters of the quality of LFDs. However, the value of FOV (in degrees) divided by the number of displayed views defines the angular resolution, which ultimately determines the smoothness of the motion parallax effect provided by the display [4]. Perceptual evaluations carried out [5] reinforce that the number of views on a given FOV directly affect QoE. Even though a smaller FOV may reduce the number of simultaneous viewers and generally limits the area in which the display can be observed, but with the same number of views, it increases the angular resolution by reducing the distance between adjacent views. Reducing FOV – without negatively affecting QoE – in order to increase the angular resolution is one of the major motivations of our paper.

III. Research Setup

We carried out our research on a LFD with a full 180 degrees viewing angle and a 30" screen (643 mm x 402 mm), with the center of the screen positioned 160 cm off ground. Only this single display was used during the subjective measurements; the changes in FOV were implemented by the displayed visual content. We rendered 4K still images as test stimuli (see Figure 1), and even though throughout the entire subjective assessment the LFD showed the image in 180 degrees, the image views outside the FOV were replaced with the background color, so the object observed from there was no longer visible. Inside the given FOV, the test participant saw the object from the correct angle; on the edge of the FOV, saw a diminishing, distorted object; outside it was just a plain color.

A total of distinct 12 test cases were defined, each with its own FOV (as it was the only varying test condition), ranging from 15 to 180 degrees. Every FOV increment of 15 degree was tested, so the chosen test cases were 15, 30, 45 degrees etc.

Fig. 1. Stimulus 1 (top), 2 (middle) and 3 (bottom) from different angles.

With 12 test cases defined, each test participant had to provide scores 36 times in total. The test cases were shown in a random order, but were clustered for stimulus, shown in blocks of 12. There were three evaluation tasks for each test:

- "Rate the field of view on a discrete scale from 1 to 10."
- "Would you personally use a display with this field of view for any purpose (work, entertainment etc.)?"
- "Would you personally spend any amount of money to own a display with this field of view?"

The lighting condition of the room the measurement took place in was 25 lux, and the display had a brightness of 150 cd/m^2. The test participants were standing during the entire measurement. They could freely view the display from any position in a 5 meters radius (where the center of the semicircle was center of the display), before making decisions. Every stimulus was displayed for 30 seconds, so the complete duration of the measurement was approximately 20 minutes. A total of 20 test participants completed the subjective measurement, with an average age of 26.

IV. Results

The Mean Opinion Scores (see Figure 2) of the gathered results show that the mean subjective assessment is nearly a linear function of FOV up to 135 degrees, and fluctuates after that. These results suggest that a FOV above 135 makes no difference in perceived quality (when concerning 180-degree LFDs and not 360-degree ones [6]). The scores of the stimuli vary, but all carry the same tendencies. Detailed statistical analysis shall be given in further dissemination of the research.

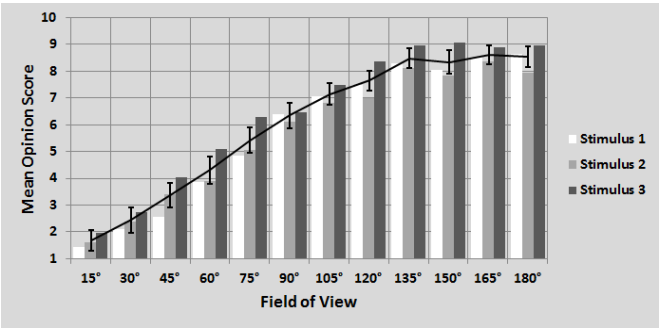

Fig. 2. Mean Opinion Scores of the subjective evaluation of FOV.

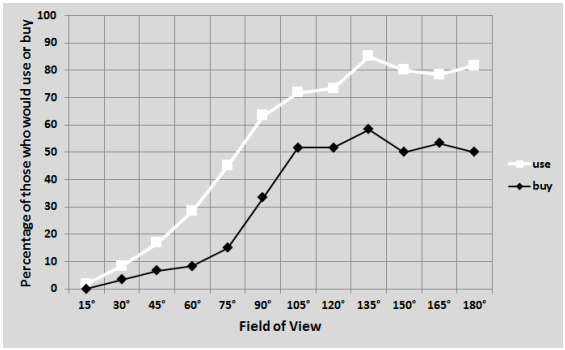

Fig. 3. Percentage of test participants who would use or buy such display.

The knowledge on QoE-influencing FOV can be used to increase angular resolution and thus make continuous motion parallax smoother. From the perspective of data transmission, however, substituting the data set of a full 180 degrees FOV with one carrying data for only 135 degrees can result in 25% decrease in the amount of transmitted data without affecting the user experience. Of course this 25% percent reduction considers a fixed angular resolution.

Our results (see Figure 3) indicate that 85% of the test participants would use an autostereoscopic display with 135 degrees of FOV, and 58% would consider making a financial investment of any extent to own an LFD with such FOV.

V. Conclusions

The paper presented the perceptual evaluation of 12 FOV values for a television-like LFD, capable of displaying visual content in 180 degrees. Tendencies found in the ratings indicate that user experience increases along with FOV until 135 degrees, but does not show significant improvement for higher FOVs. For WTP, 105 degrees is already a decisive point, but the willingness to use continues to rise beyond that value.

References

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