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Viewing experience of 3DTV: An exploration of the feeling of sickness and presence in a shopping mall

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ABSTRACT

The adoption and deployment of 3DTV can be seen as a major step in the history of television, comparable to the transition from analogue to digital and standard to high definition TV. Although 3D is expected to emerge from the cinema to peoples' home, there is still a lack of knowledge on how people (future end users) perceive 3DTV and how this influences their viewing experience as well as their acceptance of 3DTV. Within this paper, findings from a three-day field evaluation study on people's 3DTV experiences, focusing on the feeling of sickness and presence, are presented. Contrary to the traditional controlled laboratory setting, the study was conducted in the public setting of a shopping center and involved 700 participants. The study revealed initial insights on users' feeling of presence and sickness when watching 3DTV content. Results from this explorative study show that most of the participants reported symptoms of sickness after watching 3DTV with an effect of gender and age on the reported feeling of sickness. Our results further suggest that the users' previous experience with 3D content has an influence on how realistic people rate the viewing experience and how involved they feel. The particularities of the study environment, a shopping mall, are reflected in our findings and future research directions and action points for investigating people's viewing experiences of 3DTV are summarized.

1. Introduction

The new wave of 3D movies being released in cinemas makes the industry scramble to expand distribution into the home, whereby the overall excellence of 3D is influenced by several factors, such as content production, required high-level of compression, requirements set by transmission channel, and finally, by the quality of the display. A number of TV manufacturers, including Panasonic, Sony, and Samsung, are active in the development of 3DTV systems [26]. Different display technologies are available on the market at the moment, stereoscopic displays based on different techniques as well as autostereoscopic displays. However, as Chen et al. state [5], none of the existing 3D systems are ideal yet. Regardless what system is used, the final quality is determined by the users' perception [16], and the manufacturers still do not really know how consumers truly feel about 3DTV [32].

Research on users' needs and expectations for 3DTV has been conducted for mobile 3DTV and video (e.g., [16,18]). The quality of experience (QoE) of different stereoscopic content was evaluated by Häkkinen et al. [12] in a qualitative study, showing that stereoscopic projection technique enhances the emotions conveyed by the film material. Moreover, Jin et al. [15] compared the qualitative user experiences based on various auto-stereoscopic 3D displays.

Typically, 3D movies are still mainly available in the cinema. In the home context however, 3D content is sparsely used. We further assume that 3D games arrive sooner in the home context than 3D movies. The requirement for 3D glasses might be less of an issue for gamers in comparison with TV consumers. Given the willingness of gamers to adopt peripherals such as 3D glasses presents some unique issues around3D for this user group. Regarding the home context there are two more issues negatively influencing the deployment and adoption of 3DTV, namely the required change of the technical equipment by households (they have to buy a new 3D screen) as well as the only slowly growing availability of 3D content for private usage.

Despite the sparse availability of 3D content outside the cinema at the moment, we are convinced that 3D will find its way to public contexts like shops, malls, corporate buildings, etc. in the near future (e.g., for delivering information and displaying advertisements). The pervasion with 3D content will take place simply

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due to its more appealing nature, and its resulting positive effect on advertisement and sales numbers. Especially auto-stereoscopic displays, once available on the market at high prices in the beginning, will lend themselves to this form of deployment.

The focus of this paper is to investigate the feeling of sickness and presence when consuming 3D content. Providing people a good viewing experience, without any negative physical effects (e.g., feeling nauseous), is the goal of industrial efforts (see Section 2 for ongoing research efforts). As 3DTV aims to reach a high level of realism and involvement, we also measured the feeling of presence when watching 3DTV. Due to the limited availability of 3DTV-equipped households for performing a field evaluation study, we set up a public evaluation study in a shopping center as part of a bigger three-day science event of the University. Empirical data on 3D experience is also relevant for the utilization of 3D setups for different purposes (e.g., simulating real situations to study users' interaction with interactive technologies).

Within this paper, we first review the related work on 3DTV, focusing on sickness and presence as two aspects of the 3D viewing experience. Subsequently, the study set-up, including challenges posed by the public context, as well as the used methods, are described in detail. Next, the main study results are presented and discussed in detail. Last, we give a conclusion on the results as well as an outlook on future work.

2. Related work

In recent years, the amount of 3D content has steadily grown and studios are producing more and more 3D movies that are spreading across the market and appreciated in dedicated cinemas. According to a recent study from NPD display research[1], the spreading of 3D HDTV technology rose 27% until September 2011. The pervasion of the home theatre market in the US with 3D technology, for instance, reaches a number of 16% and grew 21% in the third quarter of 2011. These numbers indicate the importance of 3D technology in the current entertainment market and pinpoint the two most important technologies.

3D HDTV devices provide a high-resolution 3D image with high levels of brightness and good contrast, which allows viewing 3D content in brightly lit rooms. 3D projectors on the other hand can produce a bigger image and are usually applied in home theatre settings where lower ambient light settings apply. The prices of projectors are significantly lower than for 3D HDTV devices. However, due to the already broader pervasion of 3D HDTV devices and the availability of traditional TV devices which may be more easily replaced by 3D technology enabled TV sets, 3D HDTV is gaining importance. Another advantage of 3D HDTV devices is that they not only support glasses-based 3D projection based on shutter-glasses (active 3D) or anaglyphic or polarization glasses (passive 3D) but also auto-stereoscopic 3D that allows the viewing of 3D content without glasses [6].

Another type of device stemming from a different area are small handheld devices like smartphones (e.g., the HTC EVO 3D Sprint[2]) that do not only allow the viewing but also the capture of 3D content. Another device that was built by Nintendo introduced 3D technology (Nintendo 3DS) also in the mobile gaming area by using a glasses-free auto-stereoscopic visualization approach. Regardless of the new technological developments and innovations, the final quality of a 3D system and content depends on the users' perception and experiences. Most studies still focus on the image quality, on technical aspects of the device, or on physiological factors of the user (e.g., [1,6,7,13,19,22,23,25,34,35]). There are only a few studies that focus on the user/viewer experience when watching 3DTV.

Jumisko-Pyykkö et al. [18] highlight that in 2008 no field study investigating users' experience with 3DTV was available. Until now, most studies have dealt with mobile 3DTV (e.g., [4,9,16–18,31]). There are only a few studies exploring 3DTV in general [27]. Furthermore, we found no studies considering the future deployment of 3DTV screens in a living room environment.

Jumisko-Pyykkö et al. [16] present a descriptive model of the quality of experience for mobile 3DTV. Thereby, the viewing experience and the visual quality (depth-naturalness, spatial, motion) are main components of the quality of experience. Further components are content and audiovisual quality. The viewing experience itself is primarily described by the following four components: ease of viewing, pleasantness of viewing, enhanced immersion and visual discomfort [16]. Ease of viewing and pleasantness describe how easy it is to concentrate on 3D content and whether it is comfortable or not to watch 3D content. Enhanced immersion refers to a high level of involvement and realism. This mainly represents the positive effects of viewing 3DTV. Visual discomforts as eyestrain, and other related discomforts as sickness or headache, summarize the negative effects that can possibly occur whilst viewing 3DTV. Further aspects of the viewing experience are the comparison to familiar technology (if the user perceives the 3D technology as an improvement compared to existing technology) and an overall impression of quality. In order to find improvements for mobile 3DTV devices, Shibata et al. [31] compared the viewing experience of watching 3D content on a mobile device with watching on a large 3D screen, highlighting the effect of smaller screen size on felt discomfort, such as visual fatigue.

In general, most of the studies on 3D experience focus on the negative experiences that may come along with watching 3D content, such as eyestrain, nausea, vertigo, etc. Sickness is one of the main discomforts that may arise after or during watching 3D content. Häkkinen et al. [12] also points out the possible influence of the digital content on the experienced sickness level. Moreover, Ijsselsteijn [14] raises the discussion on the effects of the used production techniques for 3D movies on the users experience.

A questionnaire investigating users' sickness is the simulator sickness questionnaire (SSQ), which was originally developed to investigate sickness symptoms in flight simulators (see [20,21]). This questionnaire has already been proven to be appropriate for exploring sickness symptoms in environments such as driving simulators, head-mounted displays, virtual games displays and mobile screens (see [10,11,17,24,27]). The SSQ has also been used for 3D content (see e.g., [10,11,17,27]), but only in an experimental laboratory setting and not in field studies. For example, Jumisko-Pyykkö et al. [17] used the SSQ to analyze the effect of time on the appearance of sickness symptoms after watching 3DTV on portable devices. They conducted five experiments where 3D content of different length was displayed to participants. Similar to previously cited studies, their results show an increase of sickness symptoms caused by watching 3DTV. In their study they especially investigated how long sickness symptoms remain after watching 3DTV. They found that this takes less than four minutes for a short viewing time (till 15 minutes), and slightly more for a longer viewing time. Additionally they found out that symptoms did not increase significantly with a longer viewing time.

Häkkinen et al.[12] and Jumisko-Pyykkö et al. [18] claim that next to negative effects such as sickness, positive experiences created by watching 3D content should also be taken into account, as they motivate people to watch 3D content. In a laboratory study, Häkkinen et al. [12]compared the different experiences viewers have after watching stereoscopic and non-stereoscopic clips. Their findings show a wide spectrum of both positive and negative experiences (e.g., realism and presence).

[1] See http://www.displaysearch.com/
[2] See http://www.htc.com/us/products/evo3d-sprint/