Comfort and Acceptability Study of 3D Devices

Jean-Marc Diverrez
Telecom Bretagne,
Département LUSSI
jm.diverrez@telecom-bretagne.eu

Alice Naylor
UBO, Master Image et Son
projet 3D-Fovéa
lal2ly@hotmail.com

Dusan Iorgovan
Telecom Bretagne,
Département LUSSI,
dusan.iorgovan@telecom-bretagne.eu

Céline Nicolas
Telecom Bretagne, Département LUSSI,
celine.correnicolas@telecom-bretagne.eu

Gilles Coppin
Telecom Bretagne, Département LUSSI,
gilles.coppin@telecom-bretagne.eu

ABSTRACT

This paper describes the implementation of an experimental procedure to study human behavior when confronted with virtual 3D content (e.g. games and movies). The study focus's mainly on fatigue measurement. The study includes the description of measurement tools, and a definition of survey questionnaires and tests. The aim of the procedure is to standardize rules and recommendations for 3D viewing.

Author Keywords

3D vision, fatigue, eye tracker, convergence-accommodation, pupil size.

INTRODUCTION

Stereoscopy is created by the eyes which, being horizontally separated by several centimetres, observe two distinct images of the same visual scene, thereby producing two different viewpoints. Binocular disparity or binocular parallax represents the relative difference in position of the projection of the same object on the retina of the eye. Disparities or differences between the retinal image of the right eye versus the left eye, located throughout the visual field outside the point set, will allow the brain to accurately reconstruct three-dimensional space.

Perception 3D Real / Virtual 3D:

In the real world, when we focus on an object, all other objects in our field of vision appear blurred. object all other objects in our field of vision will appear clear. In a real scene when we look at an object, our eyes converge and adjust on it. The object is therefore located at our focal distance (see Figure 1).

In a 3D scene, focus is made naturally on the object (here, the projection screen) and our eyes converge on virtual objects which are projected in the space in front of us [1].

But because of our reflexes, when an object is projected into virtual space, our eyes want to adapt their shape as required and change focal distance. However, if this happened, we would focus on the 3D effect, and the film (screen) would seem blurred – and we wouldn't be able to follow the movie. We make the first eye movement but not the second. The illusion forces our eyes to converge without adjusting. This inevitable "decoupling", spread out over 90 minutes at the cinema, has beenprove to be out of the major cause of asthenopia (eye fatigue) related to 3D[2].

The wide diffusion of James Cameron's Avatar, considered as the first major movie in 3D, allowed a real life test of 3D virtual acceptability.

Following the release, ophthalmologists have now begun to receive their first patients, mainly for migraines during or after the showing[3] .

The purpose of this study is to establish a measure of 3D acceptability, in order to record and quantify the inconvenience caused, and implement standardization rules and recommendations for 3D viewing. The purpose of this paper is to present the measurement chain, for measuring

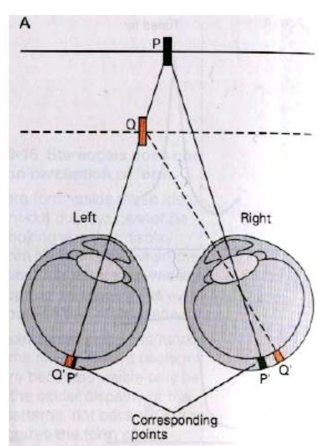

Figure 1. Convergence/Accommodation disparity.

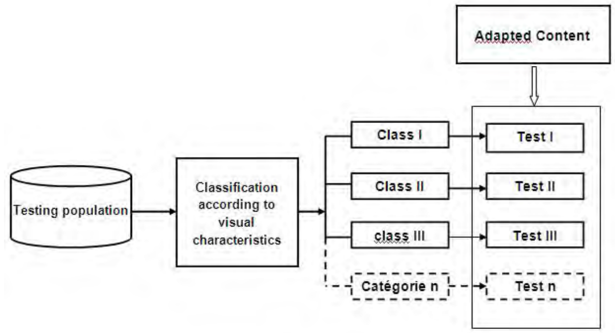

Figure 2. Organization chart of 3D-Fovéa project: Test platform -CHU-contents producer.

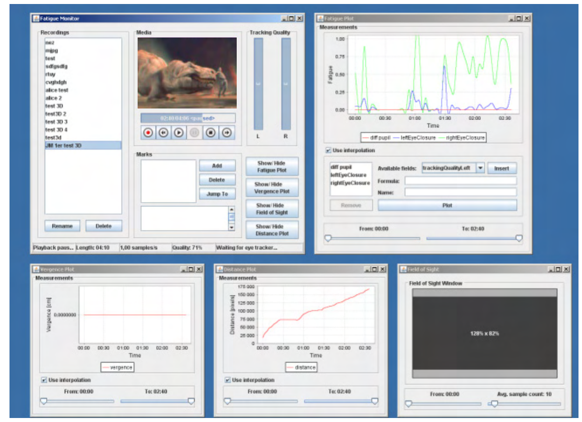

Figure 3. Fatigue-Monitor Software screen shot.

the impact of 3D visualisation for users. This approach is based principally on fatigue measurement.

Literature

Studies have already been made on the topic of fatigue and 3D vision. In 2008 Hoffman et al. conducted a study on convergence- accommodation[1] conflicts. Earlier, in 1997, Tetsuri and Hitoshi made the link between the measure of accommodation and convergence, and explored the possible interpretations of pupil size. They showed that when the virtual image and the screen were close enough, convergence followed accommodation. On the other hand, in the case of hyper-stereoscopy there is a conflict between these two criteria, which can generate fatigue. They then showed that the pupil size was smaller when viewing a 3D image, but failed to link the size of the pupil to fatigue[2].

Harle et al. have been able to show a relationship between the size of the pupil and migraines[4]. In 2006 Kazuhiko Ukai worked on fatigue and accommodation-convergence, associated with a 3D images[5]. These studies imply that accommodation and convergence appear to be relevant in fatigue studies, and permit us to consider specific changes to test conditions and to include other parameters.

MATERIAL & METHODS

Materials

We use several 3D display devices, various types of active glasses (Eyes triple shut, Nvidia, Expand) different means of visualization (3D projector, 3D screen) and a variety of content (images, games, movies). Our first tests are on games, using the 3D vision[6] from Nvidia.

Steps

The measurement chain is based on the eye tracker (Seeing Machines, FaceLab). We developed software Fatigue-Monitor (see Figure 3) for this project and allows us to evaluate the raw data of the eye tracker. This application works as a plugin for The Observer[M]. We developed this application in Java language. Essentially, its main task is to recover, display, and store the data logged from the eye tracker.

Measure Criteria

The study aims to measure several physiological criteria, related to fatigue and eye discomfort, and then to establish a link between these results and compare them with the results obtained by questionnaire from the subject (see below).

FaceLab directly computes the PERCLOS[1], a factor representing the fatigue. Our work commences utilizing this parameter to which we will then add additional factors. We aim to study the dynamics of convergence and more specifically, the decoupling of vergence-accommodation. We hope to observe the evolution of visual scanning across the screen and to monitor the total distance travelled by the eye. Finally, we will consider pupil dynamics. The Fatigue-Monitor software has been designed in a flexible manner and allows us to integrate new factors, as they arise (Figure 4).

Protocol

For more accurate results, in each test, a comparison between 2D and 3D will be made. In order to avoid any bias in the results the running order will be continuously reversed. The comparison of 2D-3D measures will allow to us to "calibrate" the results based on the subject.

Survey

We have developed questionnaires based on the SSQ of Kennedy et al.[7] and the questionnaire of Witmer and Singer[8]. A questionnaire will be completed at the end of the experiment and a second, the day after, in order to identify any potential impact of 3D vision in the delayed term. These questionnaires have been used in the past and adapted, notably to cover augmented reality, by Sophie Côté and Stéphane Bouchard[9].

PRELIMINARY RESULTS

The first test results were used to calibrate the measurement chain, using controlled stimuli. Further tests were

[1] A metric for fatigue based on the percentage the eyelid that is closed over the pupil in a given time window.

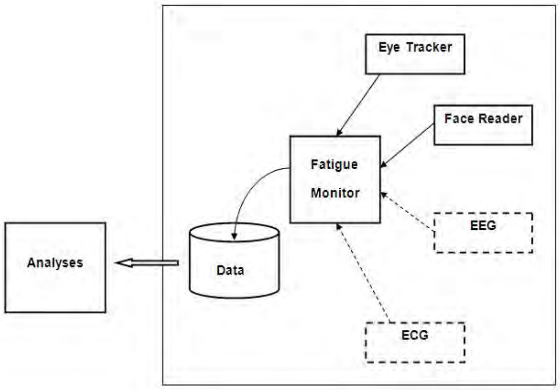

Figure 4. Fatigue monitor environment.

undertaken with 3D. After completely calibrating the measurement chain the platform was rendered operational. The first test was operated on two persons with different inter ocular distance (I.O.D.).

The curve of the first tester with small I.OD, is increasing faster, and stronger than the second tester with normal I.O.D. (see Figures 5 and 6).

CONCLUSION

The objective of the project is to establish a testing procedure based on tools such as an eye tracker and questionnaires. In order to implement standardisation rules we will be conducting tests on 50-100 people so as to verify our methods and conclusions. The project will involve the CHU, for two specific reasons: to define new relevant criteria for the test procedures and the characterisation of subjects as a function of their binocular vision characteristics. The project must also involve content producers who will be able to develop appropriate stimuli for our tests and subjects (see Figure 2). In the short term, we plan to incorporate our measurement tools over a range of visualisation equipment (screen, video projector..).

We have not yet considered the auto stereoscopy concept which has similar issues. It will be part of future developments.In the near future it is planned to link in new measurement tools to the test platform, for example thermal cameras, and new physiological sensors (EEG, ECG in particular).

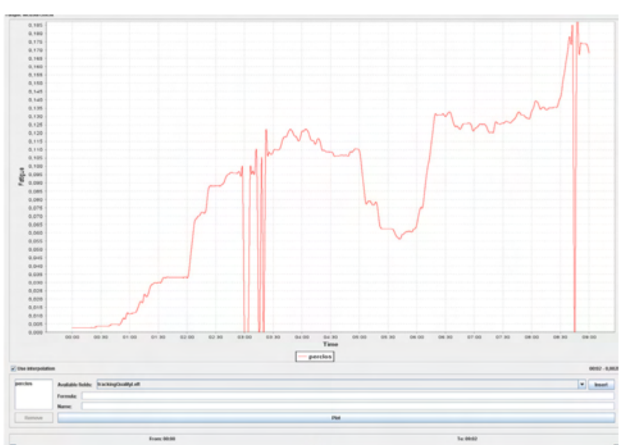

Figure 5. Perclos small I.O.D. : 57.7mm.

Figure 6. Perclos Normal IOD : 65mm.

REFERENCES

1. Hoffman, D.M., Girshick, A.R., Akeley, K., & Banks, M. S. Vergence–accommodation conflicts hinder visual performance and cause visual fatigue. *Journal of Vision*, *8*, 3 (2008), 1-30.
2. Inoue, T. and Ohzu, H. Accommodative responses to stereoscopic three-dimensional display. *Applied optics*, *36* (1997), 19.
3. Granet D. 3D headache may be ‘avatar’ of strabismus or other binocular vision condition. *European Society of Cataract and Refractive Surgeons*, avril 2010.
4. Harle, D.E. ,Wolffsohn, J.S., Evans, B. J.W. The pupillary light reflex in migraine, In *Ophthalmic & physiological optics* , *25*, 3, (2005), 240-245.
5. Ukai, K. Human factor for stereoscopic images. In IEEE Int. Conf. on Multimedia and Expo, (2006), 1697-1700.
6. Nvidia 3D Vision

   http://www.nvidia.fr/object/GeForce_3D_Vision_Main_fr.html
7. Kennedy, R. S., Lane, N. E., Berbaum, K. S. and Lilienthal, M. G. Simulator sickness questionnaire: an enhanced method for quantifying simulator sickness. *International Journal of Aviation Psychology*, 3, 3 (1993), 203-220.
8. Witmer, B.G. and Singer, M.J. Measuring Presence in Virtual environments.In *Teleoperators and Virtual Environments*, *7*, 3 (1998), 225–240.
9. Côté, S. and Bouchard, S. Documenting the Efficacy of Virtual Reality Exposure with Psycho physiological and Information Processing Measures. *Applied Psychophysiology and Biofeedback*, *30*, 3 (2005), 217-232.