IMPACT OF THE RESOLUTION ON THE DIFFERENCE OF PERCEPTUAL VIDEO QUALITY BETWEEN CRT AND LCD

Sylvain Tourancheau, Patrick Le Callet and Dominique Barba

Université de Nantes – IRCCyN laboratory – IVC team
Polytech'Nantes, rue Christian Pauc, 44306 Nantes, France
sylvain.tourancheau@univ-nantes.fr

ABSTRACT

The incoming of the high-definition new visual experience at home has boosted the new display technologies such as liquid crystal displays (LCD), plasma and projectors. These technologies enable the increase of the screen size necessary to sense a cinema-like experience. However, they introduce some new visual shortcomings not present with the mature CRT technology.

In this paper, some subjective tests are described which highlight a difference of the perceptual video quality between CRT and LCD. Moreover, it's observed that this loss of quality on LCD is more important with high resolution sequences than with standard resolution ones. This influence of the resolution is particularly explainable in the case of the LCD motion blur defect.

Index Terms— Quality control, Liquid crystal displays, Cathode-ray tubes, Image resolution, HDTV.

1. INTRODUCTION

High-definition television (HDTV) broadcasting systems will soon substitute the standard television (SDTV). With the incoming of this new visual experience in terms of pictures resolution, some new display technologies have grown. They enable the increase of the screen size necessary to sense immersion, impact and immediacy as in a movie theater [1]. However, these new display technologies, such as liquid crystal displays (LCD) and plasma, introduce some new visual shortcomings [2] and make the compression distortions more visible than on CRT [3].

Moreover, it has been shown that a larger picture resolution becomes a drawback when the level of coding distortions increases: the observers then prefer a lower resolution as this reduces the visual impact of the distortions [4]. It could be interesting to know if the same behaviour appears with some display-dependent visual defects.

In this paper, subjective quality assessment tests are described in Section 2. They're performed for both HDTV and SDTV sequences, on both CRT and LCD. A difference of perceptual video quality between CRT and LCD is highlighted in Section 3. Moreover, these results show that the loss of quality on LCD is larger with high resolution sequences. Section 4 is a discussion of the results.

2. SUBJECTIVE QUALITY ASSESSMENT

2.1. Material

Four ten-second long 1080i[1] HDTV sequences from SVT research have been used (namely *New Mobile and Calendar*, *Parkrun*, *Shields* and *Stockholm*). Each reference (uncompressed) sequence has been distorted with H.264 compression standard using JM reference software. Seven bit-rates (not necessary the same for each sequence) have been chosen to cover the entire quality range.

The SDTV sequences are computed from these HD sequences through a half-band filtering followed by a down-sampling operation by a factor of 2 (both along horizontal and vertical directions). This processing is performed on each field of the interlaced HD sequence. The resulting 540i sequences are an approximation of the actual SDTV whereof format is 576i, with the advantage that it does not necessitate any interpolation. As for the HD ones, the SD sequences have been coded using the H.264 JM reference software, with the same parameters. Six bit-rates (not necessary the same for each sequence) have been chosen to cover the entire quality range.

The tests have been performed in a specific showroom. The lighting conditions and the display parameters have been measured and adjusted according to the ITU recommendations BT.500-11 and BT.710-4. Two HDTV displays have been used: a CRT (JVC DT-V 1910CG) and a LCD (Philips T370 HW01) which both can display the 1080i format. Viewing distance was set to $3H$ for HD sequences and $6H$ for SD sequences (where H is the height of the screen), according to recommendations. Tests have been led in four parts: HD sequences

[1] 1080i format: 1920×1080 resolution in interlaced mode

on a CRT, HD sequences on a LCD, SD sequences on a CRT and SD sequences on a LCD.

2.2. Observers

The observers were mainly (about 80%) students between 20 and 25 and the gender parity was almost respected (about 2/3 of male). All were familiar with standard television and cinema but not with HDTV. The acuity and the colour perception of each observer have been checked, respectively with Monoyer's plates and Ishihara's test for colour blindness. The observers with at least on error in Ishihara's test or with an acuity less than 9/10 was rejected. Between 20 and 25 subjects took part in each of the four tests, there was not the same people from a test to another.

2.3. Protocol

The assessment method required here should allow observers to precisely construct their judgment. As very little quality differences must be detected, the method must force the quality discrimination. A well known stable method for this purpose is the SAMVIQ method [5], developed by France Telecom R&D and standardised by the EBU and the ITU.

SAMVIQ is a multi stimuli continuous quality scale (MSCQS) protocol. It provides a precise and reliable [6] measure of the subjective video quality which can be compared directly to the reference. Actually, the observers compare several sequences to assess both between them and with an explicit labelled reference. This feature permits a high degree of resolution in the grades given to the system. Moreover, observers have a random access to the sequences, which permits to choose exactly the sequence they want to assess. This allows them to precisely build their assessment opinion. This is particularly interesting in this context where very little quality differences have to be identified. The notation scale is continuous: each score can take a value between 0 and 100.

In the HD assessment, the set of sequences to assess is composed by seven distorted sequences, a version of the reference (uncompressed) sequence hidden among the impaired ones, and a explicitly labelled version of the reference sequence. Thus, a total of nine sequences has to be evaluated by the observers. In the SD assessment, there are six impaired sequences and so eight sequences to assess.

The consistency of the individual scores is evaluated after the tests have been completed by all the subjects. This is done by applying a suitable "rejection" technique from the EBU [5]. Following the application of this rejection process, 15 valid subjects should be retained at minimum.

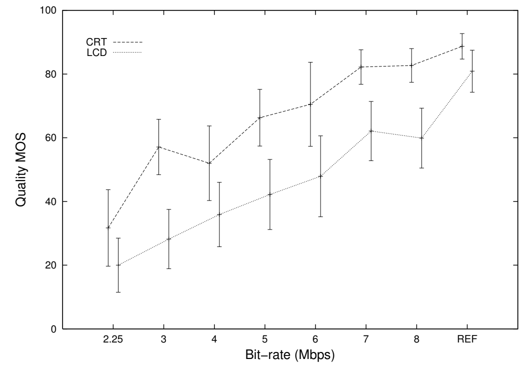


Fig. 1. Quality mean opinion scores as a function of bit-rate for HD version of the sequence *Shields*. Results are plotted for the two displays. The horizontal shift between the two sets is for clarity.

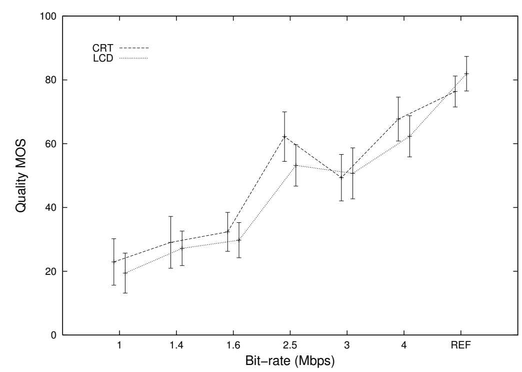
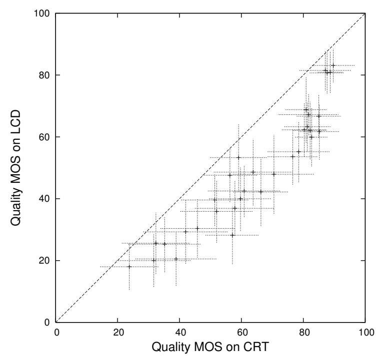


Fig. 2. Quality mean opinion scores as a function of bit-rate for SD version of the sequence *Shields*. Results are plotted for the two displays. The horizontal shift between the two sets is for clarity.

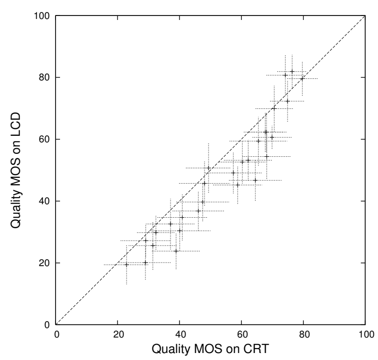
3. RESULTS AND OBSERVATIONS

The quality mean opinion scores (MOS) are plotted as a function of the used bit-rates in Figure 1 for the HD versions of the sequence *Shields*. Both the MOS obtained on LCD (continuous line) and those obtained on CRT (dashed lines) are presented in the figure. The farthest points on the right (with the abscissa named REF) are the MOS of the hidden reference. With high resolution materials, it can be observed that there is a certain difference of perceived quality between CRT and LCD, in favour of CRT. The same quality scores are plotted in Figure 2 for the SD versions of the sequence *Shields*. In the case of standard resolution materials, the difference between the two displays is not so conspicuous. Moreover, with regard to the confidence intervals this gap is not statistically reliable.

In order to have a global view of these results, the quality MOS obtained on LCD have been plotted as a function of the quality MOS obtained on CRT in Figure 3. At the top (Figure 3a), the MOS of the eight HD versions of the four sequences are plotted. At the bottom (Figure 3b), the MOS of the seven SD versions of the four sequences are plotted. In HD, the points are globally shifted towards the area where the MOS on CRT are higher than those on LCD. For SD materials, it's less blatant. The points are nearer to the frontier than for HD materials and for most of them the confidence intervals are overlapping this limit.



(a) The eight HD versions of the four sequences



(b) The seven SD versions of the four sequences

Fig. 3. LCD quality mean opinion scores as a function of CRT quality mean opinion scores.

4. DISCUSSION

4.1. Visual shortcomings of liquid crystal displays

An ITU study [2] describes some subjective tests which have been conducted with HDTV sequences in order to compare the perceived quality between CRT and LCD. It has resulted that, as a whole, the majority of the observers felt that the picture quality on LCD was lower than the one on CRT. Many defects have been counted by the viewers. Despite of recent improvements, the LCD motion blur remains annoying for moving pictures with significant movements. On LCD, the dark areas look glossy or lighter than on CRT. The differences of reproduced colours has been also observed between CRT and LCD, particularly with flesh colours. Concerning the overall impression, the observers generally notice that there is no depth-feel in the images and sequences displayed on LCD. CRT produces more natural feelings and textures than LCD.

The LCD motion blur has been widely studied in recent works [7, 8, 9]. It's mainly caused by the hold-type LCD's displaying method: the light intensity is maintained on the screen for the duration of the frame, whereas on CRT the light intensity is a pulse which fades over the frame duration. The main difference happens when the eyes of the observer are tracking a moving object on the LCD screen: for a given frame, the picture is sustained on the screen while the eyes are still moving slightly, anticipating the movement of the object. The edges of this object are displaced on the retina, resulting in a blur [10].

4.2. Impact of LCD motion blur

Some recent results [11] have shown that the difference of perceptual quality between CRT and LCD devices for moving pictures could be roughly predicted from the quantity of movements in the sequence. The width W (in pixels) of the LCD motion blur that appears on the edges of a moving object is proportional to its velocity V (in pixels per frame) as follows [8, 12]:

$$W = aV, \tag{1}$$

where a is a parameter which depends on temporal aperture of the display.

The computation of an average edges' velocity along the sequence enables to estimate a global magnitude of the perceived blur. It appears that for sequences with significant movements the loss of quality on LCD devices is linearly related to this magnitude.

4.3. Influence of resolution

The results of the subjective quality assessment tests presented in this paper show that the difference of quality between CRT and LCD is larger with HDTV sequences than with SDTV ones. In other terms, the increase of the display resolution seems to amplify the LCD visual defects. In the particular case of LCD motion blur, this could be easily explained. In SDTV, the velocity of moving objects is reduced by two with respect to HDTV. According to the previous statements, the magnitude of the perceived LCD motion blur is reduced in the same proportion. The loss of quality on LCD should be roughly two times less important in SDTV than in HDTV.

Previous work [13] has shown that some sequences in a NTSC format (525i) obtain best subjective quality scores on a 5.5 inch LCD monitor with a CIF resolution ($352\times$ 288) than on a 20 inch CRT monitor with a NTSC resolution. It means that the perceived quality on LCD at low resolution (CIF format) is better than the perceived quality on CRT at standard resolution. These results are in continuity with ours: the visual quality is roughly the same on CRT and LCD at intermediate resolution (SDTV format) and the perceived quality on CRT is higher at high resolution (HDTV format). The display resolution has an important influence on the visual defects affecting liquid crystal displays. These visual defects seems to be more visible at high resolution than at low resolution.

5. CONCLUSION

Some subjective video quality assessment tests have highlighted a difference of perceptual quality between CRT and LCD devices. Moreover, this difference is very more important on high resolution sequences than on standard resolution ones. This loss of quality on LCD can be explained by the visual defects affecting this new display technology. The influence of the display resolution on the perceptual video quality on LCD has been explained for the motion blur issue. Of course, the increase of pictures resolution in HDTV leads to broadcasting issues such as the increase of minimal acceptable bit-rates. But less blatantly, it appears that the visual shortcomings relative to new display technologies are worsened by this display resolution increase. Liquid crystal display technology has to be improved in order to reach the visual quality of CRT, particularly in HDTV. However, more reduced video applications supports such as laptop, cell phone, personal digital assistants, etc. are not as much affected by these visual defects due to their smaller display resolutions.

6. ACKNOWLEDGEMENT

This study is supported by a student grant from the French région Pays de la Loire, it falls also within the framework of the French national research project Scalim@ges. The authors would like to thank Arnaud Tirel and Romuald Pépion for their assistance in performing the experiments described in the paper.

7. REFERENCES

[1] T. Fujio, "Future broadcasting and high definition television," Tech. Rep., NHK, 1982.

[2] ITU, "Report on results of comparative subjective picture quality assessment test between CRT and LCD," Tech. Rep., Radiocommunication Study Groups, 2005.

[3] EBU, "Maximizing the quality of SDTV in the flat-panel environment," Tech. Rep., Broadcast Technology Management Committee, 2004.

[4] S. Péchard, M. Carnec, P. Le Callet, and D. Barba, "From SD to HD TV: effects of H.264 distortions vs display size on quality of experience," in *Proc. of the Int. Conf. on Image Processing, ICIP*, 2006.

[5] EBU, "SAMVIQ – Subjective assessment methodology for video quality," Tech. Rep., Project Group B/VIM, 2003.

[6] J.-L. Blin, "New quality evaluation method suited to multimedia context: Samviq," in *Proc. of the 2nd Int. Workshop on Video Processing and Quality Metrics, VPQM*, 2006.

[7] M. A. Klompenhouwer, "The temporal MTF of displays and related video signal processing," in *Proc. of the Int. Conf. on Image Processing, ICIP*, 2005.

[8] H. Pan, X.-F. Feng, and S. Daly, "LCD motion blur modeling and analysis," in *Proc. of the Int. Conf. on Image Processing, ICIP*, 2005.

[9] X.-F. Feng, "LCD motion-blur analysis, perception, and reduction using synchronized backlight flashing," in *Proc. of the SPIE Conf. Human Vision and Electronic Imaging XI*, 2006.

[10] T. Kurita, "Moving picture quality improvement for hold-type AM-LCDs," *SID Symposium Digest of Technical Papers*, vol. 32, pp. 986–989, 2001.

[11] S. Tourancheau, P. Le Callet, and D. Barba, "Prediction of perceived quality differences between CRT and LCD displays based on motion blur," in *Proc. of the 3rd Int. Workshop on Video Processing and Quality Metrics, VPQM*, 2007.

[12] S. Péchard, S. Tourancheau, P. Le Callet, M. Carnec, and D. Barba, "Towards video quality metrics for HDTV," in *Proc. of the 2nd Int. Workshop on Video Processing and Quality Metrics, VPQM*, 2006.

[13] M. H. Pinson and S. Wolf, "The impact of monitor resolution and type on subjective video quality testing," Tech. Rep., NTIA, 2004.