Impact of the resolution on the difference of perceptual video quality between CRT and LCD

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

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ABSTRACT

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

In this paper, subjective tests are described which highlight a difference of perceptual video quality between CRT and liquid crystal displays. 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 for 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 standard television (SDTV). With the incoming of this new visual experience in terms of pictures resolution, new display technologies have grown. They enable the increase of 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 compression distortions more visible than on CRT [3].

It has been shown that larger pictures resolution becomes a drawback when the level of coding distortions increases: observers then prefer standard definition as this reduces the visual impact of the distortions [4]. It could be interesting to know if the same behaviour appears with 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, results show that this loss of quality on LCD is larger with high resolution sequences. Section 4 is a discussion of these results.

2. SUBJECTIVE QUALITY ASSESSMENT

In this part, subjective quality assessment tests are described. The perceptual quality of HDTV and SDTV sequences is assessed on both CRT and LCD.

2.1. Material

Four ten-second long 1080i 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.

SDTV sequences are computed from these HD sequences through a half-band filtering followed by a downsampling by a factor of 2 (both along horizontal and vertical directions). This processing is performed on each field of the interlaced HD sequence. Resulting 540i sequences are an approximation of actual SDTV whereof format is 576i, with the advantage that it doesn't necessitate any interpolation. As with HD sequences, SD videos have been encoded 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.

Tests have been performed in a specific showroom. Lighting conditions and display parameters have been measured and adjusted according to BT.500-11 and BT.710-4 ITU recommendations. Two HDTV displays have been used: a JVC DT-V 1910CG and a Philips T370 HW01 which both can display 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 on a CRT, HD sequences on a LCD, SD sequences on a CRT and SD sequences on a LCD.

2.2. Observers

Observers were mostly male students in their mid twenties. All were familiar with standard television and cinema but not with HDTV. Every candidate has been first checked for color blindness with Ishihara test and for acuity with Monoyer's plates. People with at least one error in Ishihara's test or less than 9/10 in Monoyer's test have been rejected. Between 20 and 25 people took part in each of the four parts tests, but there was not necessary the same people from a part 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 European Broadcasting Union (EBU). Observers compare seven distorted sequences (for HD content, six for SD) and one hidden reference both between them and with the explicit reference. Notation scale is continuous, each score can take a value between 0 and 100.

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. It is important to note that this reference may or may not be the original video signal. As the observers can directly compare the impaired sequences among themselves and against the reference, they can grade them accordingly. 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 consistency of the individual scores is evaluated after the tests have been completed by all the subjects. It is done by applying a suitable "rejection" technique. This is a process in which all scores from a particular subject are omitted from the analysis of data. Following the application of the rejection process, 15 valid subjects should be retained at minimum.

3. RESULTS AND OBSERVATIONS

Quality mean opinion scores (MOS) are presented in Figure 1 for the sequence *Shields* as a function of the used bit-rates. These MOS are plotted both for CRT and for LCD tests. 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 difference of perceptual subjective quality between CRT and LCD, in favour of CRT.

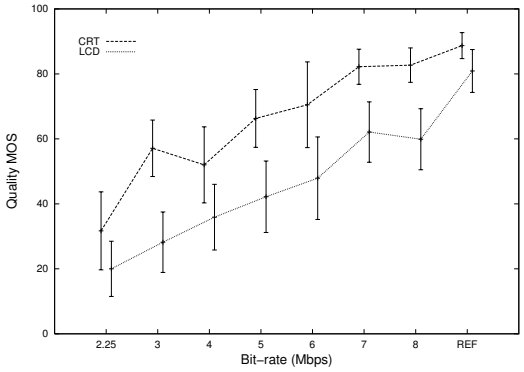


Fig. 1. Quality mean opinion scores obtained with HD, for the two types of displays, as a function of bit-rate, for the sequence *Shields*. The horizontal shift for each data point is for clarity.

Same quality scores are shown for the SD versions of sequence *Shields* in Figure 2. In the case of standard resolution materials, the difference between the two displays is not so conspicuous. CRT scores are a little higher than LCD ones, but with regard to confidence intervals it's not statistically reliable.

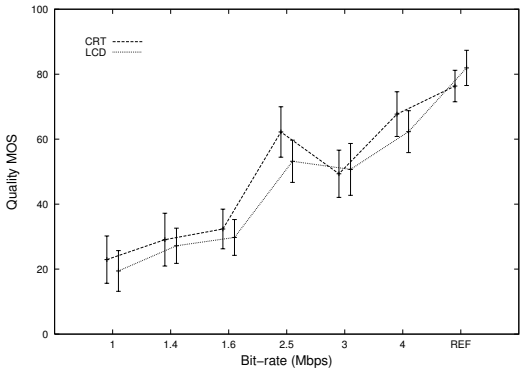
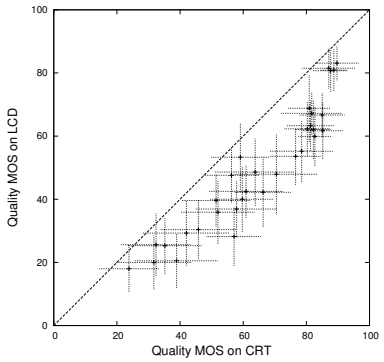
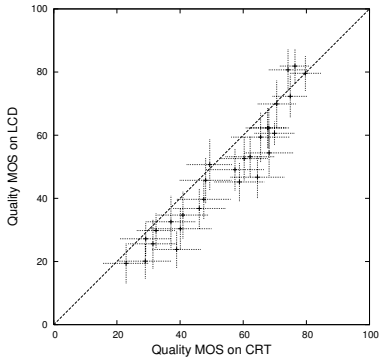


Fig. 2. Quality mean opinion scores obtained with SD, for the two types of displays, as a function of bit-rate, for the sequence *Shields*. The horizontal shift for each data point is for clarity.



(a) 8 HD versions of the 4 sequences



(b) 7 SD versions of the 4 sequences

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

In order to have a global view of these results, quality MOS obtained on LCD devices have been plotted as a function of quality MOS obtained on CRT displays in Figure 3. At the top (Figure 3a), MOS of the eight HD versions of the four sequences are plotted. At the bottom (Figure 3b), MOS of the seven SD versions of the four sequences are plotted.

HD quality MOS are globally shifted towards the area where CRT MOS are higher than LCD ones. For SD materials, it's less blatant, points are nearer the frontier than for HD materials. Moreover, confidence intervals are widely overlapping this limit.

4. DISCUSSION

4.1. Visual shortcomings of liquid crystal displays

Subjective tests have been conducted with HDTV sequences in order to compare quality picture between CRT and LCD [2]. It has resulted that, as a whole, majority of the observers felt that the picture quality on LCD was lower than the one on CRT. Many defects have been counted by viewers. Despite of recent improvements, motion blur remains still annoying for moving pictures with significant movements. The luminance at black level is higher for LCD monitor, so that black areas look glossy or lighter than on a CRT. Difference in reproduced colours has been also observed between CRT and LCD, particularly with flesh colours. Concerning the overall impression, observers generally notice that there is no depth-feel in images displayed on LCD. CRT produces natural feelings and textures while on LCD images are displayed too sharply, leading to unnatural perspective.

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 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. Edges of this object are displaced on the retina resulting in a blur [10].

4.2. Impact of LCD motion blur

Recent study has 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 motion blur that appears on the edges of a moving object is proportional to its velocity V (in pixels per second) as follows [8]:

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

with a 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 perceived motion blur. It appears that for sequences with significant movements the loss of quality on LCD devices is linearly related to this magnitude [11].

4.3. Influence of resolution

The results of 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 display resolution seems to amplify 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 in terms of resolution (pixels per second) with respect to HDTV. According to previous statements, the magnitude of perceived motion blur is reduced in the same proportions. The loss of quality on LCD should be roughly two times less important in SDTV than in HDTV.

Previous results [12] show that some sequences at NTSC format (525i) obtain best subjective quality scores on a 5.5 inch LCD monitor with a CIF resolution (352× 288) than on a 20 inch CRT monitor. The perceptual quality on LCD is better than those on CRT at low resolution (CIF format). These results are in continuity with ours: LCD and CRT visual quality score are almost the same in intermediate resolution (SDTV format) and CRT perceptual quality 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

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 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. seem to not be as much affected by this visual defects due to their smaller display resolutions.

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