Digital cinema commercials in Norway – is the quality good enough?

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Abstract

In this paper we describe the partial results of a collaborative research project conducted by researchers at Gjøvik University College and Lillehammer University College. The goal of the project is to develop methods and tools to improve the control of color information in the production and presentation of digital video. The project represents a unique attempt to bring together two scientific communities – graphic arts and television/video production – on a theme of common interest, namely color. We have investigated the color quality achieved by a system for digital distribution and presentation of cinema commercials. Our results show that the "quality bottleneck" is the digital projector. Especially in large theaters, the "business-type" projector does not yield sufficient image quality.

1 Introduction

Ever since the beginning of the color film era, color adjustment has been a permanent area of difficulties in the production of moving pictures (Roderick, 1976). The use of several cameras simultaneously or at different times and under varying lighting conditions, results in varying color rendering in the different captured shots. When these shots are edited together, the colors must be harmonized, and this requires substantial manual adjustments. The fact that shots are often taken under lighting conditions which are different from the those desired to tell the story, has also led to extensive color corrections by use of color filters and laboratory chemicals.

The introduction of video technologies changed the methods of work, but color corrections remained a tedious process, requiring expensive equipment for use in professional environments. The transition from analog to digital video now opens the possibilities for developing methods of video color management, by applying principles similar to those already in use for digital image reproduction on various media (Kraushaar and Gall, 2002). Digital video color management can potentially be implemented using common computer platforms, and equipment which cost a fraction of today's dedicated video editing and color correction equipment. At the same time, the processes can be simplified and made less time-consuming. Such solutions will have the potential of strengthening smaller production environments with limited resources and increasing the possibilities for distributed production of video material.

In a collaborative research project involving researchers from the neighboring institutions Gjøvik University College (GUC) and Lillehammer University College (LUC), it was decided to investigate further into this interdisciplinary area of research and development. The research project was funded by Morgenlandet AS, a regionally based company which aims for restructuring and innovation, and has a duration of two years (2002-2003). It brings together two scientific communities – color science and color management mainly for graphic arts applications at GUC, and video, television, and film production at LUC.

In a recent interview, Garrett Smith of Paramount Pictures states, when discussing the problems with varying aspect ratio in digital television: "Please be careful before you trespass on the visual integrity of these motion pictures" (Fisher, 1999). This quote can serve as a motivation for the present study. Whether the film-maker's goal is to convey realism – a sense of 'being there' – to invoke certain emotions, or to use the diverse symbolic meanings of color, color is a very important part of the visual integrity of motion pictures (Jørholt, 1998). Our overall goal is to make sure that the creative use of color in the production of all types of moving pictures is not compromised because of technological limitations. Obviously, a great deal of what it would take to achieve this lies completely out of our reach, so we decided to limit our scope to digital video. This is partly because of the obvious flexibility inherent to digital video processing using today's powerful computers, but also because digital video technology is now very quickly replacing traditional film technology for many applications. This is particularly true for amateur video production and digital broadcast television, but also the concept of *digital cinema* is now being introduced (Manovich, 2001; Korris and Macedonia, 2002).

We have identified four different research topics of particular interest (Andresen *et al.*, 2001):

1. Color management in the acquisition of digital video.

This topic includes problems such as automatic white balance, colorimetric characterization of cameras, and the use of color targets in the acquisition process.

2. Color control for editing of digital video. Here we pay specific attention to the tasks typically performed by a colorist – adjusting colors of video sequences in order to obtain certain effects/moods, and also to match the colors of other sequences (Hardeberg *et al.*, 2002).

3. Color characterization of monitors used in the production of digital video. Here we investigate how color management principles, typically ICC-based, can be applied to a video production environment in which several different monitors are used simultaneously.

4. Color quality of projective displays used for presentation of digital video. The use of digital projective displays for the presentation of moving pictures is growing rapidly, both in a home theater environment, and in public movie theaters. However, very little scientific work has been published on the colorimetric characterization of such displays, and on the resulting color quality. Does the quality match conventional cinema technology? Does the presented colors appear the way the producer intended them? We address these questions both through visual assessments and by using advanced measurement instruments such as a spectroradiometer (Hardeberg *et al.*, 2003; Seime and Hardeberg, 2003).

In sum, our overall approach to color management in digital video is to strive for consistent, repeatable, and automatic processing of color information in all parts of the production and presentation chain, except in the editing phase, where creativity is desired.

In this paper we present the results of the fourth research topic above. First, in Section 2 we describe a new system for digital distribution and presentation of cinema commercials. In Section 3 we present our analysis of the quality of the images produced by this system, before concluding in Section 4.

2 Digital video in cinema theaters

2.1 Introduction

In the beginning of 2002 a system for digital distribution and presentation of cinema commercials was introduced in Norway, and by now, almost all movie theaters use this system (Kleja, 2002). Although the introduction of digital cinema commercials has not created much public attention in Norway, there have been some voiced concerns about the image/video quality produced by the system.

To our knowledge, Norway is the first country to introduce digital technology at this scale into movie theaters. It is probable that this might be a first step towards using digital technology also for feature length movies. This definitively increases the relevance and interest of examining the digital cinema commercials system in a D-Cinema context (Korris and Macedonia, 2002).

2.2 The system

The digital cinema commercials system is managed by a Norwegian private company, which through association with other companies, controls both the technical and commercial aspects of the distribution and projection of commercials, and to a certain extent also their production. There are no longer any alternatives for traditional distribution and projection of analog 35mm cinema commercials.

In the system, the commercials are first digitized using telecine equipment, if they are produced on traditional 35mm film. However, more and more commercials are now produced digitally. The change towards digital production has probably been accelerated because of the fact that the two main channels where the commercials are shown, television and cinema, now both make extensive use of digital technology for distribution and presentation.

The digital footage, typically either in DigiBeta or DV format, is then compressed to 15 Mbit/s using the MPEG-2 scheme, and distributed to the movie theaters by satellite. In the theaters, the commercials are stored and managed on dedicated computer systems.

Finally, typically just before the feature movie presentation, preprogrammed sequences of commercials, so-called "playlists," are presented using digital projectors. One interesting feature of the system is that the selection of commercials can easily be targeted towards the audience of particular movies.

The projectors used in the system are of two main types, high-resolution digital cinema projectors using 3-chip DLP technology, and conventional business-type projectors using LCD technology. The differences in price, spatial resolution, and brightness are indeed non-negligible.

3 Quality analysis

Within the framework of a collaborative research project focusing on color issues in the production and presentation of digital video, we decided to examine this new system, particular addressing its color image quality. The main goal of our project was to carry out qualitative and quantitative measurements and evaluations of different parts of the new system for distribution and projection of digital cinema commercials, in particular with regards to color and visual quality. The project has been carried out partially by students in media technology and graphic arts engineering (Døvre *et al.*, 2002).

Ideally, we would have preferred to compare the quality of traditional 35mm film with that obtained with the digital

system, but unfortunately we were not able to collect test material on traditional film, partially due to the fact that the commercials are now mostly produced digitally. We therefore decided to focus on whether the digital medium was used to its full potential, that is, if different parts of the system induced quality reductions as compared to high quality digital video. The compression and projection stages were analyzed in particular. Important tools that were used in our project include interviews and questionnaires, "blind tests" with a panel of observers, and spectroradiometric measurements in which color changes due to compression were evaluated.

3.1 Visual tests

In order to evaluate the quality of the system, we created a test movie containing elements from real movie commercials as well as test sequences prepared by the Norwegian Broadcasting Corporation. This test movie, originally in DV format, was compressed using the actual system, and also using an MPEG-2 encoder with varying degrees of compression. We selected three different versions of the movie for further tests; the original DV version (25Mbit/s), the version compressed by the system (15Mbit/s) and a version compressed to 2Mbit/s.

First, the original DV version and and the cinema commercial system version were shown to a panel of 16 observers in a movie theater, using the business-type projector. The panel was asked to answer nine questions by selecting the most appropriate answer, see Figure 1. When asked about their first impression of the quality of digital cinema commercials, only one person (6%) in the panel gave a negative answer. However, when asked if they noticed artifacts that reduced the quality, 15 persons (94%) answered yes.

Secondly, a quality evaluation experiment ("blind test") was carried out. The three versions of the test movie were shown simultaneously side by side, with one side mirrored, as illustrated in Figure 2. The identities, i.e. compression technology, of the movies were not identified to the panel. For each of the six possible combinations, the panel was asked to identify which side they considered to have best quality. This corresponds to the quality evaluation protocol known as pair comparison which is based on Thurstone's law of comparative judgment (Gescheider, 1985). No significant quality difference was found between the uncompressed DV version and the one compressed by the system, in fact, equally many preferred one over the other. The one compressed to 2Mbit/s was consistently judged to be of inferior quality.

3.2 Measurement based tests

We also carried out spectroradiometric measurements of a standard test image shown on a reference video monitor in order to evaluate unwanted color changes due to the video compression used in the system, see Figure 3.

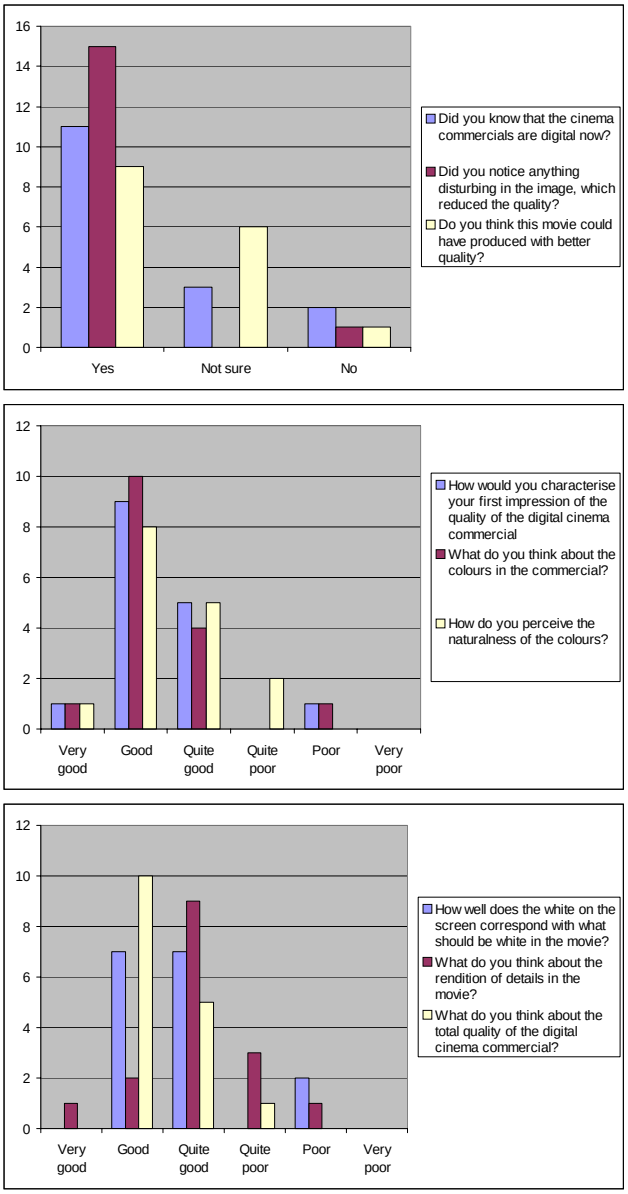

Figure 1: Results of the questionnaires concerning the quality of digital cinema commercials.

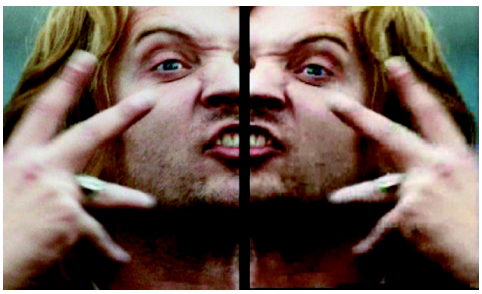

Figure 2: Split screen arrangement for pair comparison blind test. The scene shown is taken from Norsk Tipping's commercial *"Taxi Driver."*

The differences were relatively large – the average color difference over 12 test colors was 7.9 ΔE^*_{ab} units, while a maximum difference of 16.6 ΔE^*_{ab} units occurred for blue. Generally the colors were desaturated by the compression. It is remarkable that despite this difference, the test panel did not find the compressed version to be of lower quality.

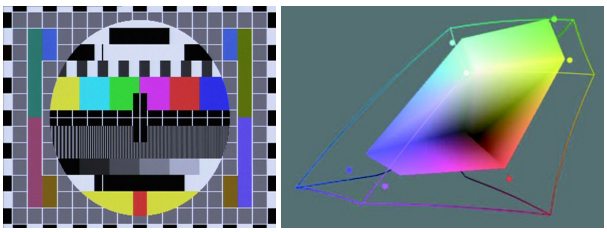

Figure 3: The standard test target used for color measurements (left), and an illustration of the resulting color desaturation introduced by the compression algorithm (right). The dots represent the original colors in the CIELAB color space, and the vertices of the solid object represent the colors of the compressed video.

3.3 Interviews and overall analysis

Interviews with the management of several movie theaters employees revealed that those who had invested in the high-end digital cinema projectors were generally satisfied with the image quality, while those who were using the business projector were more concerned. However, most of them were very positive to the new system, because of its simplicity and flexibility.

From visual judgments, we noticed varying degrees of artifacts such as white-outs and excessive contrast in the business projectors, while with the high-end digital cinema projectors, the overall quality was judged to be very good.

This, together with the experimental results presented above (i.e. that no visual quality reduction was introduced by the compression), leads us to conclude that the most critical quality factor in the system is the digital projector.

4 Conclusion

The present study has shown that the "quality bottleneck" of the new Norwegian system for distribution and presentation of cinema commercials is the digital projector. Especially in large theaters, the "business-type" projectors do not yield sufficient image quality. The MPEG-2 video compression used in the system does not introduce visible quality degradations, although color differences can be measured.

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References

Andresen, S., Farup, I., Hardeberg, J. Y., Korten, J. U., Skarsbø, S. E., and Stjernvang, G. (2001). Fargestyring i produksjon og presentasjon av digital video. Gjøvik University College Report Series 2, Gjøvik University College. (In Norwegian: Color management in the production and presentation of digital video).

Døvre, H., Hofslundsengen, R., Førland, J. I., and Czari, R. (2002). *Digital Kinoreklame*. Project report, bachelor programme in graphic arts engineering, Gjøvik University College. (In Norwegian: Digital Cinema Commercials).

Fisher, B. (1999). Interview with Rob Hummel and Garrett Smith on digital introspection. Available online e.g. at http://stage.postindustry.com/article/mainv/0,7220,110133,00.html.

Gescheider, G. A. (1985). *Psychophysics, Method, Theory, and Application*. Lawrence Erlbaum Associates, 2 edition.

Hardeberg, J. Y., Farup, I., Øyvind Kolås, and Stjernvang, G. (2002). Color management for digital video: Color correction in the editing phase. In *Proceedings of the 29th International Iarigai Research Conference*, Lucerne, Switzerland.

Hardeberg, J. Y., Seime, L., and Skogstad, T. (2003). Colorimetric characterisation of projection displays using a digital colorimetric camera. In *Projection Displays IX*, volume 5002 of *SPIE Proceedings*, pages 51–61, Santa Clara, California.

Jørholt, E. (1998). Colour in cinema – a white spot on the film scholar's map. In K. Blomstrøm, editor, *Colour between Art and Science*, pages 82–103. National College of Art and Design, Department of Colour, Oslo, Norway.

Kleja, M. (2002). Reklam i ettor & nollor. *Ny Teknik*. Online: http://www.nyteknik.se/pub/ipsart.asp?art_id=20678. (In Swedish: Commercials in ones & zeros).

Korris, J. and Macedonia, M. (2002). The end of celluloid: Digital cinema emerges. *Computer*, **35**(4), 96–98.

Kraushaar, A. and Gall, D. (2002). ICC color management within the motion picture industry. In *Proceedings of IS&T and SID's 10th Color Imaging Conference: Color Science and Engineering: Systems, Technologies, Applications*, pages 212–216, Scottsdale, Arizona.

Manovich, L. (2001). *The language of new media*. MIT Press, Cambridge, Massachusetts. See also the author's web site at http://www.manovich.net.

Roderick, R. (1976). Color in the motion-picture industry. *SMPTE Journal*, **85**, 496–504.

Seime, L. and Hardeberg, J. Y. (2003). Colorimetric characterisation of LCD and DLP projection displays. *Journal of the Society of Imaging Display*, **11**(2).