Standards Update

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Six of the seven Technical Committees of CIE Division 8 met in Scottsdale, AZ in conjunction with the recent IS&T 10th Color Imaging Conference. In addition, Todd Newman, Director of CIE Division 8, presented a Division 8 update as part of the conference. Therefore, it seems appropriate to make CIE Division 8, Image Technology, the focus of this Standards Update.

My appreciation to Todd for allowing me to plagiarize from his presentation, and to Todd and Mike Pointer (CIE Division 8 Editor) for reviewing and correcting this update.

Background

CIE Division 8 was formed in 1998 in response to a request from industry, most vocally expressed at a CIE Color Experts meeting held at the end of the 1997 Color Imaging Conference. Its charter is

> "*To study procedures and prepare guides and standards for the optical, visual and metrological aspects of the communication, processing, and reproduction of images, using all types of analogue and digital imaging devices, storage media and imaging media*."

There are currently seven Technical Committees within Division 8 which we shall visit shortly.

In the introduction to his presentation, Todd noted that "to do its job well CIE Division 8 must balance the needs and tendencies of current practice, standardization, commercial development, and color science. Each brings value to our work: there is much accumulated wisdom embedded in current practice; standardization can harmonize our practices; commercial development brings innovation and accommodates individual preferences; and our work is most useful when grounded in scientific knowledge.

But each of those forces can also be a problem when it is excessively dominant. We are trying to solve problems that have not been solved by current practice, so too much inertia will prevent progress. Unchecked the standardization process can bring about excessive regulation and conflicting standards. The commercial desire for "product differentiation" can prevent users from getting predictable results. Color scientists face a large and complex problem; it will be years or decades before they can reach a robust general theory."

TC8-01 Color Appearance Modeling for Color Management Applications

The CIECAM97s color appearance model (CAM) represented a consensus opinion among a set of color scientists in CIE TC1-34. However, as color engineers applied this model in the imaging industry, they found problems. The goal of TC8-01 is to find ways to improve the model, based both upon the earlier consensus and upon more recent data and experience.

In its recent meeting the TC reported that a proposed revision of CIECAM97s, to be called CIECAM02, is in the final stages of documentation. The revision has a linear, and therefore easily invertible, chromatic adaptation transform. It has revised lightness and chroma scales that better fit the experimental data.

Clarifications have been made in setting the parameters for the model. Finally, several of the equations within the model have been simplified to improve computational speed.

The result should be more useful to both color scientists and color engineers. Following a vote by Division 8, the report should be ready for voting by the CIE in time for the CIE Session in San Diego, CA in July 2003.

TC 8-02 Color Difference Evaluation in Images

The goal of TC8-02 is to derive an industrial color-difference evaluation method that is appropriate for complex images (rather than uniform patches). Current color difference formulas (CIELAB, CMC, etc.) are designed for color patches that subtend 2 degrees or more of the field of vision. Color areas in images tend to be much smaller. The method must be based on a quantitative model of color-differences under conditions typical of commercial imaging applications.

This TC started off trying to respond to requests from the user community by racing to form a standard very quickly. However, it found that neither is there common practice in industry nor is there much academic research upon which to base a standard.

Therfore, the TC will have to first develop a consensus among experts by encouraging and co-ordinating appropriate research. The final report of this phase of the TC's work is in preparation and will be a Technical Report on Methods to derive color differences for images. It will include:

- a color difference equation with an option to add spatial filters
- a method for evaluating color reproduction fidelity including test images
- experimental data sets available on the web
- a summary report on a collaborative research programmed for investigating the perceptibility and acceptability thresholds using a set of color difference images based upon SCID/XYZ images across different test sites.

The TC plans to provide Division 8 with a voteable draft technical report by December 2002. Following a vote by Division 8, the report should be ready for voting by the CIE before the CIE Session in San Diego, CA in July 2003.

This report will be used to coordinate further testing of the color difference equation with and without the spatial filtering. This will give the information needed to eventually develop a standard in this area.

TC 8-03 Gamut Mapping

The goal of TC8-03 is to study, develop and recommend a baseline solution for cross-device and cross-media image reproduction, a process commonly known as "gamut mapping." Such a solution would provide a standard procedure to calculate the color gamut of an image, an imaging system, or its components, and either one algorithm, or a set of algorithms and rules for use in specific applications.

The TC faces a challenge greater than the usual lack of consensus about best practices. Many industry experts believe that selecting an acceptable gamut mapping algorithm is always image-dependent, and that we cannot select a fixed set of rules that will always yield an acceptable reproduction. Some companies believe that they have a proprietary advantage to their gamut mapping algorithm, and so they do not want a standard to be created. Both sets of beliefs make it hard to come to a consensus. However, a standardized baseline behavior is vitally important for reliable and unambiguous communication of color information across networks.

Therefore, the goal of the TC is to try to forge agreement, again by using the technique of coordinated research.

The TC has decided to proceed by first developing a standard experimental design for gamut mapping research. The design requires standard experimental conditions, some standard algorithms to be tested in each experiment, and some standard images to be used in each experiment. If researchers use this design, it will be possible compare results between experiments which has not generally been possible in the past. Intercomparison of results should allow the color community to converge upon a baseline more rapidly.

The TC has prepared a draft technical report recommending a standard experimental design for gamut mapping research. The TC should vote on it in late 2002, and Division 8 and the rest of the CIE in 2003. Of course, this represents only the first step in the process. The research must be performed and the results compared before a standard can be formulated. While it would have been nice to have a recommendation by now, color practice can best be influenced by work based on sound research rather than arbitrary standards,

TC 8-04 Adaptation Under Mixed Illumination Conditions

The task of TC 8-04 is to build on the work done by TC 1-27 and extend it in a manner to make it more useful to color practitioners. TC 1-27 has done fine work on appearance matching between video displays (soft copy) and paper (hard copy). However, their work requires that people completely adapt to each viewing condition.

Both consumers and professional graphic artists want to compare an electronic original side by side with its hard-copy reproduction. This causes some problems for color scientists. The primary one is figuring out what stimulus will appear white to observers in this situation because each has a different white point. As most color appearance models do, both CIECAM97s and the new CIECAM02 require a white point to be specified. It is well known that typical observers find neither paper white nor the monitor white to be a "true white" in this situation.

The TC compared results from several experiments. All the experiments found that observers were between 40% and 60% adapted to the video display and 60 to 40% adapted to the ambient illumination. This may seem like a wide range, but it should be expected.

Fairchild and Reniff, in"Time Course of Chromatic Adaptation for Color-Appearance Judgments," J. Opt. Soc.Am. A 12, 824-833 (1995), suggested the possibility of two mechanisms for chromatic adaptation. The first being a rapid mechanism with a time constant of 0.9 to 1.5 second, and the second being a slower mechanism with a time constant of 38 to 53 second. The visual system reaches a 60% adaptation level within a few seconds, but takes minutes to reach full adaptation.

If observers are glancing back and forth between monitor and a print, they are not fully adapting to either level. Since the amount of time observers spent with each fixation were not controlled in the experiments evaluated, it must expected that experimental results will show a wide range of adaptations.

TC8-04 feels that they have gleaned as much as they can from this research. They plan to produce a draft technical report by the end of 2002 to be voted on by Division 8 and the rest of CIE in 2003. The report will propose a simple extension to color appearance models like CAM02 to account for mixed adaptation.

TC 8-05 Communication of Color Information

The aim of TC8-05 is to standardize a minimal set of techniques that enable unambiguous and efficient communication of the color information in images. This is critical at this point in time, as the color standards community is currently is developing many different proposals for standard color encoding, e.g., e-sRGB, eg-sRGB, scRGB, ROMM-RGB, RIMM-RGB, etc..

TC8-05 does not plan to put forward yet another standard color encoding. Instead, its purpose is to help rationalize the process and, hopefully, to minimize the number of standard color encodings. TC8-05 is hoping that it can help the other standards bodies by providing a methodology that can help them select new color encodings, or between existing color encodings, in a more methodical manner. Their plan is to develop appropriate criteria and metrics to serve as a guideline. The TC is also working with other standards bodies to develop application profiles that may be used to weight the relative importance of the individual components in the metrics.

The members of CIE TC 8-05 have proposed a series of criteria to evaluate the characteristics of various color encodings. These criteria included:

- Encodeable gamut volume characteristics,
- Color quantization efficiency and error characteristics,
- Visual uniformity,
- Complexity of transformation required to and from typical standard spaces (sRGB, ICC PCS, etc.),
- Compressibility,
- Compatibility with standard workflows (e.g., Photoshop software), and
- others to be determined.

The TC has already prepared metrics for the absolute and relative size of the encodable gamut, quantization error and efficiency, and encoding complexity. Standards bodies can then decide which criteria are important to its clientele, and use the CIE's method for quantifying the degree to which a proposed standard meet those criteria. TC8-05 plans to have a set of evaluations available by the end of this year. They will produce a draft technical report in 2003.

TC 8-05 Vocabulary

You might think that vocabulary was not a technical issue, but it is. Often, the most heated arguments actually spring from inconsistent use of terminology. Terms such as "contrast" and "flare" can have very different uses in different technical fields. As these fields are brought together through the use of computer systems, inconsistent use of terminology can lead to inconsistent use of technology.

The work of this technical committee is to create a master vocabulary of technical terms relating to image technology. This may either supplement the International Lighting Vocabulary or be published as a separate document. Of course, this is another area in which it is important to form and maintain active liaison with other standards bodies.

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sures to be printed at the digital service laboratories like CeWe. CeWe transfers every image to a CD as well.

In Dr. Treiber's lecture "Digital Printing in Wholesale Finishing" a few facts deserve mention. Agfa introduced its DPS digital printer in 1991; later they used it for index printing in the APS system. Its introduction made reversal color paper obsolete. Gretag in 1998 introduced Syntra. Agfa in 1999 HIT for Dima. Envelopes with memory cards or CDs are now used. Image files are being transferred at POS stations to MODS via DSL lines or via Internet from POS and also via Internet posting from and to end users.

Gretag uses a DLP exposure system from Texas instruments with vibrating micro mirrors as a modulating element. The paper speed is 52 cm/ sec, achieving 20,000 4 x 6 inch prints per hour. Kodak's i.lab uses laser exposure and a scanner/printer. It can do 10,100 prints per hour. Agfa's d-print lab 20, to be marketed in 2003, uses laser exposure at 85 cm/ sec, achieving 19,800 prints per hour. Gretag's DLP exposes one pixel every 100 µsec, using conventional color paper in the process. Agfa and Kodak expose one pixel every 30 µsec.

All the parameters for film quality enhancement are applied to the digital printing process. Digital laboratories can manage with 50% fewer staff members. Order finishing is simpler and faster without film. Printing is more constant and error-free without film. There is no film processing and handling or care for the negatives to be saved as originals by the customers. There is automatic batch sorting and automatic order input with digital printing available, according to Treiber.

The digital camera user takes twice as many pictures, but prints only 5%. With 40% replacement of traditional film cameras, where 60% are active cameras, by digital cameras, which have 5% prints made from twice as many exposures, a drop to 5% prints is a significant business loss. Last year a drop of 3% was experienced in Germany, in Japan 10%.

There were essential discussions on the slide-viewing style of digital image use. Reiner Schorscht, an owner of many shops and purchaser for 2000 small photo dealers, expressed a concern with reeducation of staff in photo shops and a concern with the reduced profit margins for digital camera customers. Film sales, picture envelope sales and d&p charges, were easy. They are being replaced by complicated computer tasks, all less profitable for the photo dealers.

The IS&T minilab symposium in Cologne served the information needs of large European finishers, like Agfa and Gretag, and their suppliers. Our conclusion was that the industry is challenged to maintain film d&p practices and to invest in digital picture-making with expensive, often unproved methods. We are curious regarding the inkjet photofinishing solution of Phogenix and cautious where the Indigo solution is concerned.

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The TC is currently collecting terms and definitions from within the CIE, and from other standards groups working in the imaging field. These will be incorporated into a draft Technical Report by the end of 2002 and be ready for balloting in 2003.

TC8-07 Multi-spectral imaging

TC8-07 is the newest Technical Committee in Division 8, and it is just getting started. In fact its first meeting was held in conjunction with the Color Imaging Conference. The terms of reference of TC 8-07 are:

> *"To study, develop, and recommend encoding techniques and data formats for the exchange of multis-pectral images, and to provide test procedures for the evaluation of multi-spectral imaging systems."*

The main topic of this first meeting was a review of the terms of reference. It was suggested that the goals should be made clearer by a few additional words including some examples of multi-spectral imaging. It was found that the focus of the TC should be on the visible range of the spectrum, while extensions into the near IR and UV should not be excluded.

It was also noted that multi-spectral imaging includes multi-spectral image acquisition systems, multispectral image encoding systems, multi-spectral images, and multi-spectral image reproduction systems such as multi-primary displays and spectral printers.

If you are interested in this work, the chair of TC 8-07 is Dr. Patrick Herzog who may be reached at P.Herzog@color-aixperts.de.

Summary

CIE Division 8 is just 4 years old. In its first four years a lot has been accomplished. Progress has been surprisingly rapid, especially for color science, most color standards groups, and certainly for color practice in general. Four of the initial five TCs in Division 8 are ready to produce a technical report. Two of the TCs will shortly have completed their tasks and will probably be closed.

The work of each TC must blend the four elements of color practice, color engineering, color science, and color standards. Those of us involved in Division 8 believe that our TC's, and the technical people involved, are finding ways to do this very successfully, and are showing remarkable progress in advancing the state of color in Image Technology.

For suggestions for future updates, or standards questions in general, please contact the author at mcdowell@npes.org or mcdowell @kodak.com