Medical Imaging Display Color Space (mRGB)
Teleconference
19 June 2014 • 09:00 (EST)

The meeting was called to order at 09:00 am (EST) by Craig Revie, acting chair, with the following attendees:

Rich Amador	Canon U.S.A., Inc.
Chris Bai	BenQ Corporation
Pinky Bautista	MGH PICT center
Vipul Baxi	Omnyx Integrated Digital Pathology
Wei-Chung Cheng	Federal Drug Administration
David Clunie	Bioclinica & PixelMed
Brian Cote	Eizo Corporation
Scott Forster	Roche Ventana
Phil Green	Gjøvik University College, Norway
Bas Hulsken	Philips Healthcare Incubator
Po-Chieh Hung	Konica Minolta
Francisco Imai	Canon U.S.A., Inc.
Bryan Kennedy	KARL STORZ Imaging
Stephen Lansel	Olympus
Changjun Li	Liaoning University of Science and Technology
Takashi Matsui	Eizo Corporation
Efrain Morales	KARL STORZ Imaging
Allen Olson	Leica Biosystems
Craig Revie	Fujifilm Corporation
Christye Sisson	Rochester Institute of Technology
John Sweeney	BenQ Corporation
Dave Wyble	Avian Rochester, LLC
Kaida Xiao	Technical Consultant
Albert Xthona	Barco NV
Masahiro Yamaguchi	Tokyo Institute of Technology
Brettle David	James's University Hospital Leeds

After a sound check for remote participants, those attending introduced themselves and identified their area of interest. Mr. Revie summarised future meetings of the ICC Medical Imaging Working Group and handed the chair to Mr Albert Xthona.

Mr Xthona reviewed the agenda for the meeting as follows [see attached]:

1. Introduction
2. Define use cases to be supported
3. Discussion on architectural choices
4. Come to conclusion on architecture for color display systems

A recording of the meeting is available to download at http://www.npes.org/Portals/0/standards/2014-06-19%2009.02%20New%20Meeting.wmv

1. Introduction

Mr Xthona outlined the history of medical imaging and the problem of representing reality [see attached]. When imaging first came in, the variability in images was recognised and there was a desire to standardise. The introduction of GSDF helped to achieve consistency. He summarised the goal of the session as agreeing an architecture for the display of medical color images.

2. Use cases

Mr Xthona summarised the possible use cases as:

1. Direct representation of grayscale images
2. Direct display of medical RGB images with no color management
3. Display of medical RGB images with color management

It was noted that case 3 (RGB with color management) was more a future case, and that a further possibility was simultaneous display of gray and RGB images with color management. In some cases the representation of text and metadata also needed to be included.

2.1 Grayscale. It was necessary to check compliance with GSDF. Often hardware LUTs were used to achieve GSDF calibration.

Displays are often 12-14 bits per channel to permit rescaling of tone curves to match GSDF. In practice non-medical displays are also used, with no GSDF calibration. There is increasing use of mobile displays for review, but for primary diagnosis medical displays are recommended and in many countries required by law.

2.2 Direct display of RGB. Different imaging modalities are supported, but the main application is pseudocolor and the task is usually detection or quantification. Annotations and text could be considered as another pseudocolor case.

2.3 RGB with color management. The main application currently is medical photography, and there is a need to work on a compatible approach that handles color correctly. The current ICC framework handles interpretation of color satisfactorily. A future possibility is that if display properties are known, software could transform images appropriately – e.g. to achieve perceptually linear behaviour. The meeting also discussed the case of synthetic images (e.g. for simulation of prostheses), where consistency or accuracy may be important but there is no original.

Dr David Clunie observed that DICOM perceptual linearization is not consistent with a CIE or ICC approach, and can generate contouring / quantization on 8-bit systems. There was a need to achieve the desired behaviour without compromising precision or contrast.

It may not be possible to support the three use cases outlined simultaneously, but it was not necessarily essential to support legacy cases. In the multi-modality case of mammography, where e.g. MRI and CT images might be viewed simultaneously, the precision of gray was critical but not of color. The meeting agreed there were three categories of consistency requirements: critical importance, needs to look acceptable, and unimportant. It also agreed that these may not be possible in a unified display architecture.

It was felt that case 2 implies that users do not care about consistency. It was possible to develop best practice guidelines for such cases, especially for legacy images, while case 3 represents the path for the future.

Mr Xthona showed the display system components [see attached]. The Displayport supports double precision images, but in practice implementations are limited to 8 bits per channel, although some demonstration systems are higher.

Mr Xthona reviewed architectural choices for medical displays, and posed four questions:

- Is DICOM GSDF compliance a requirement?
- Is it possible to calibrate a display simultaneously to sRGB and to perceptually linear behavior?
- Is a new ICC rendering intent for 'perceptually linear color behavior' needed?
- Should mRGB be used to encode color images for non color management-aware applications?

Dr David Clunie stated that the purpose of the GSDF was to achieve consistency in medical displays so that grayscale contrast is always the same. It was originally intended to show a match between a display and a radiology film viewed side by side. If consistency can be achieved by other means, GSDF may not be needed. In modalities where color accuracy is important, such as dermatology, colors would not match since GSDF would conflict with calibration for color accuracy (particularly on hybrid systems), and color management using ICC profiles would be the best solution.

It was noted that if the pipeline is limited to 8 bits per channel, quantization is likely when mapping to GSDF.

The meeting then addressed the second of the questions above. The idea is essentially to extend the perceptually linear behaviour of GSDF to color, which would ensure consistency in presentation of RGB images. It was observed that in ICC color management the exchange space (the Profile Connection Space) is CIELAB-based, and therefore perceptually linear to the same degree as the CIELAB system. It was suggested that using the ICC Media-relative Colorimetric rendering intent with Black Point Compensation (MRC+BPC) should achieve the same results as the GSDF pipeline.

Dr Po-Chieh Hung presented some work on micro and macro color differences [see attached]. He showed differences in color arising from using GSDF against L*. The full presentation will be discussed in a future teleconference.

It was agreed that it was important to preserve linearity of luminance, but not necessarily of color. The CIELAB colour space provides an approximate uniformity of colour.

Dr Bas Hulsken suggested that there was no use case for mixing radiological and color images. The need for consistency of user interface was noted.

Most non-GSDF images are encoded as sRGB, but modern displays exceed the sRGB dynamic range and color gamut. It was suggested that the imaging pipeline could include gamut expansion to an extended gamut intermediate encoding before compressing as needed to the actual display gamut. Dr Po-Chieh Hung suggested that image sharpening might allow a reduction in the number of colors needed.

Dr John Penczek stated that his goal was to preserve the accuracy of sRGB, and it was noted that this could be achieved if the workflow honoured the embedded sRGB ICC profile.

Mr Xthona observed that this works for images where the profile is embedded, but (addressing Q3 above) currently-available rendering intents do not support re-scaling for perceptually linear color behaviour; one useful task would be to define such a rendering intent. Mr Craig Revie responded that PLCB is similar to MRC+BPC, and this could be investigated further. There was a need to understand the use cases to map and how the mapping should be constrained. An option was to indicate the desired perceptual uniformity of the image through an additional tag. It was agreed that it was important to retain consistency with the existing architecture as far as possible.

Mr Xthona showed a strawman architecture proposal. He summarised the discussion during the meeting, noting there was agreement on the following:

a. The use cases as defined in 2. above.
b. The need to support each of the use cases.
c. The need to define the accuracy of the ICC architecture for use case 3.

The next step would be to take the proposed architecture for medical display color and test using the existing ICC architecture to determine its accuracy. Tests could include physical, numeric and analytical.

Mr Xthona agreed to prepare a summary of the meeting for the Friday plenary with the FDA and to plan a teleconference to continue the discussion. The meeting closed at 12:00.

Action items:

MIWG-14-30 Test accuracy of ICC architecture in reproducing medical color images (all)
MIWG-14-31 Prepare summary for FDA plenary (Xthona)
MIWG-14-32 Plan teleconference to continue discussion on medical display architecture (Xthona)