
Recommendations from the Summit on Color in Medical Imaging and Implications for Laboratory Practices

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Summit on Color in Medical Imaging

- Public workshop co-sponsored by FDA and ICC (International Color Consortium) held May 8-9, 2013 at FDA White Oak campus
- Endorsed formally by AAPM and DICOM
- Full title: “Summit on Color in Medical Imaging: An International workshop on the Technical Framework for Consistency and Interoperability Approaches for Dealing with Color in Medical Images.”
- Purpose: To bring together key stakeholders to clearly identify areas of need, investigate solutions and propose best-practice approaches in the handling of color in medical imaging.

Summit on Color in Medical Imaging

- Areas of medicine represented:
 - WSI, Digital Microscopy, and Histopathology
 - Color Standardization in Digital Microscopy by Y Yagi
 - Color in Histopathology Imaging by D Treanor (UK)
 - Color Within the Context of WSI by S Hewitt
 - The Biological Stain Commission by B Boyce
 - Endoscopy and Laparoscopy
 - Dermatology, Ophthalmology and Medical Photography
 - Telemedicine and Displays (including mobile)
 - Standards and Measurement

Summit on Color in Medical Imaging

- Program committee:
 - David Clunie, Corelab Partners, PixelMed, DICOM
 - Tatsuo Heki, FUJIFILM, DICOM
 - Hideto Yokoi, Kagawa University, DICOM
 - Veronika Lovell, Sun Chemical, ICC
 - Craig Revie, FFEI, ICC
 - Aldo Badano, CDRH, FDA
- 28 speakers (12 Americas, 5 Europe, 6 Japan), 120 participants (80% industry).
- Program and webcast in FDA website (<http://www.fda.gov/MedicalDevices/NewsEvents/WorkshopsConferences/ucm342138.htm>) and at ICC website (<http://www.color.org>).

Summit: key question

- What one step, if any, would you suggest we take in order to improve the handling of color in medical imaging systems within your area of expertise?

Preview of WSI recommendations

- Scope:
 - Color in digital imaging in histopathology imaging including telepathology and photomicroscopy, with emphasis on WSI and automated image analysis.
- Why and how is color relevant?
 - Digital pathology highlights color differences between samples, laboratories and scanning systems. Differences are visible and affect results of image analysis algorithms.
 - Workflow improvement in digital mode up to 30%.
 - Still no hard evidence of effect on diagnostic performance, particularly for difficult cases.

Preview of WSI recommendations

- Major consensus points:
 - Significant variability in color (examples given).
 - Variation in color at all stages: from sample to slide preparation, imaging, transmission to display.
 - Distinction between color variation occurring before imaging and during or after imaging.
 - Color reproducibility was agreed to be important, but its importance depends on intended use: Human observers may be more tolerant of variability than image analysis algorithms.

Preview of WSI recommendations

- Major roadblocks:
 - Significant variability in histochemical staining between and within laboratories.
 - Standardizing pre-imaging sample handling steps in acquisition, fixation, processing, sectioning and staining is a difficult task.
 - Significant variation in performance among scanners
 - Lack of availability of color calibration for scanners.
 - Preliminary work in such a target was presented.

Preview of WSI recommendations

- Next steps:
 - Initiate efforts to characterize and address color variation and discussion about collaborative efforts.
 - Investigate the extent of color variation among scanners and reasons for the variability.
 - Develop international standards on color reproduction, technology to apply standardization from the glass slide to the display monitor.
 - Understanding in the general pathology community of the importance of such work.

Initiatives from the Summit

- Calibration slide for histopathology
- DICOM camera raw & EXIF tags
- Medical RGB Color Space – mRGB
- Framework for multispectral imaging
- Open source reference implementation
- Color support for mobile devices
- Best practices for color in DICOM
- Connectathon to check color capability
- Best practices for digital medical photography
- Calibration standard for ophthalmology

Calibration slide for histopathology

■ Problem statement

- One reason for differences in whole slide imaging is the lack of a suitable calibration process which means that the same slide can look very different from system to system.

■ Proposal

- Vendors that have worked in this area should pool their resources to develop a calibration system for digital microscopes.

■ Participants

- Organizations: ICC, DICOM WG26, FDA.

DICOM camera raw & EXIF tags

■ Problem statement

- Today DICOM provides support for JPEG images, however the objective for these images is not colorimetric but to provide a good looking image.

■ Proposal

- Extend DICOM to provide support for Camera RAW image format and to include metadata from EXIF tags to provide data needed to derive the colorimetry of a scene.

■ Participants

- Organizations: ICC, DICOM WG13, ISO TC42.

Medical RGB Color Space - mRGB

- Problem statement
 - There is no suitable color display calibration objective for medical imaging displays designed for color images.
- Proposal
 - Define a set of colour spaces and ICC profiles for medical displays using the GSDF as the greyscale "Medical RGB Color Space - mRGB".
- Participants
 - Organizations: AAPM WGMD, ICC.

Framework for multispectral imaging

■ Problem statement

- Some medical imaging makes use of multispectral images but no suitable framework is defined for their storage, communication and display.

■ Proposal

- Define a multispectral imaging framework.

■ Participants

- Organizations: DICOM WG26, CIE TC8-07, ICC.

Open source implementation

- Problem statement
 - Integrating ICC color management with viewer software can be difficult and sometimes results in a product with poor performance.
- Proposal
 - Connect the ICC's open source 'Sample ICC' or similar CMM with an open source DICOM viewer.
- Participants
 - Organizations: ICC.

Color support for mobile devices

■ Problem statement

- Mobile devices (smartphones, tablets...) do not usually support color management directly and any color framework needs to be able to accommodate this class of device.

■ Proposal

- Develop guidelines for color support on mobile devices.

■ Participants

- Organizations: ICC.

Best practices for color in DICOM

- Problem statement
 - Current DICOM could provide support for accurate colour if used correctly but in many (most) cases colour metadata is ignored.
- Proposal
 - Develop guidelines for each imaging modality and where possible a set of tests for conformance.
- Participants
 - Organizations: ICC, DICOM WG, IHE.

Connectathon for color capability

- Problem statement
 - There is no way for systems developers to check that colour aspects of their latest developments are compatible with other products.
- Proposal
 - Connectathons provide an environment where developers work directly with each other with technically competent arbiters.
 - Demonstrations at meetings.
- Participants
 - Organizations: ICC, DICOM.

Best practices for medical photography

■ Problem statement

- It might not be easy for a medical photographer to know how best to capture and communicate color images.

■ Proposal

- Develop best practice guidelines for medical photography including jpeg and raw use cases

■ Participants

- Organizations: NIST, U of Rochester.

Calibration standard for ophthalmology

- Problem statement
 - Color differences in the appearance of the retina in fundus imaging is the lack of a suitable calibration standard.
- Proposal
 - Develop a suitable calibration phantom and method and best practices to ensure color consistency across devices and manufacturers.
- Participants
 - Organizations: U of Rochester.

Summary

- General agreement on need to advance interoperability and consistency of color handling in medicine (imaging).
- Consensus paper to be published in 2013.
- Working Group on Color in Medical Imaging formed under ICC
(http://color.org/groups/medical_imaging_wg.xalter).
- Several initiatives in planning stages.