



**Medical Photography task force
Teleconference
9 April 2015 • 10:00 (EDT)**

The meeting was called to order at 10:00 am (EDT) by Craig Revie, the MIWG chair.

After a sound check, Mr Revie listed forthcoming meetings of MIWG, including multispectral imaging (subject to confirmation), and a review of the FDA guidance on whole-slide imaging devices. He also noted the forthcoming Colour and Visual Computing Symposium on 25-26 August in Gjøvik, Norway. He handed over the meeting to Dr Penczek, who introduced the latest version of the medical photography workflow document [see attached].

1. Guidelines document

Dr Penczek reviewed the motivation, mission and scope of the document. He also summarised the comments received from the prior meeting, and discussed how these comments were addressed. A revised version of the draft guidelines was presented based on the received comments. The draft allowed for the user to capture images by two shooting methods. The sequential method would capture a reference colour chart (e.g. Macbeth ColorChecker) as one in a series of images taken of a subject in a stable lighting and capture environment. The side-by-side method would require that the reference colour chart be placed beside the subject for each image capture. Each of these methods could have two workflow, depending on the type of images captured: one based on camera RAW and one on rendered JPEG images.

In the discussion, it was suggested that the guidelines should be open to vendor-specific technologies, and not related solely to output. It was also suggested that the document put the image capture process in context to the larger workflow, which included output devices. Dr Penczek stated he wanted to identify several viable image capture colour-correction workflows, and not limiting the recommendations to a single technology. It was agreed to defer this issue for the time being, and possibly consider use of iccMAX for some elements of the workflow.

Dr Penczek reviewed other changes in the document. Dr Flynn stated he liked the open approach being taken, and the use of both commercial and open-source materials.

Dr Flynn recommended that the studio images illustrating diffuse illumination in Figure 1 be replaced with medical-specific examples. Dr Penczek requested the member's help in obtaining such images.

The meeting discussed the recommendations on illumination. Dr Flynn suggested it was essential to acknowledge the use of less-than-ideal illumination, such as ring flash. It was reported that the ColorChecker has minimal specular reflection, so non-diffuse illumination should not make a large difference when capturing the colour target. The meeting agreed that the main characteristics of recommended sources should be given, but not specific details.

The meeting reviewed the workflow diagram. It was agreed that RAW should be the main workflow. A dermatologist attending the meeting stated that although the detailed procedure and flowchart were

valuable, he requested that simplified versions of these also be provided. Dr Penczek agreed and added that the document was intended not just as a guide for the medical photographer, but also to help companies design better solutions for the user. Dr Flynn offered to request input on this draft from a medical photography professional at his institute.

Dr Xiao inquired about the possibility of including a validation check to ensure that the colour-correction was working correctly. Mr Revie suggested that this would be a good topic to follow up on with Dr Xiao and Mr Vogh after the meeting.

Dr Penczek reviewed the tentative outline of a publication, and indicated that he would like to start on writing up the document. The meeting considered whether to meet at the MIWG meeting in Tokyo, but it was felt that the date was too soon to have made enough progress.

2. Arri stereoscopic imaging microscope

Harald Brendel of Arri introduced the Arri 3000ppi 2-lens stereoscopic imaging microscope. This has white LED illumination, recording capability and an autostereoscopic display. It has recently been launched and is undergoing documentation and certification. Mr Brendel reported that the tolerances for colour accuracy (inter-instrument agreement and reproducibility) were acceptable, and he described the error metrics and test samples used. It was confirmed that the calibration transform was built for specific device components, for binocular viewing. It was suggested that a further dedicated meeting on colour in microscopy would be useful.

Mr Revie thanked the participants and closed the meeting at 11:00.

Action items from the meeting:

MIWG-15-09 Continue work on guidelines document (Penczek)

Action items from previous meetings:

MIWG-14-23 Provide draft description of camera characterization procedure (Green)

MIWG-14-24 Provide reference to X-Rite flesh tone colour samples (Lianza)

MIWG-14-25 Consider providing a description of the calibration procedure (Vander Haeghen)

Recommended Image Capture Workflow for Medicine Photography

John Penczek

March 24, 2015

Introduction:

This general procedure outlines a recommended digital camera image capture workflow that can be used to improve image color accuracy and consistency. The process it outlined in the flowchart given in Annex A. The implementation of this workflow would be especially beneficial for use cases where color accuracy is critical, such as dermatology, plastic surgery, pathology, and wound documentation. It should also be noted that since medical photographs are part of a patient's record, they are subject to privacy considerations.

Required equipment:

- Digital color camera with white balancing capability.
- Reference color test chart. May be a commercial color chart (e.g. from X-Rite, DSC Labs, QPcard, Douglas color card, etc...) or one designed for the application. The color chart should come with the corresponding measured color data.
- Light source and background that can provide uniform hemispherical illumination over the camera field of view. The light source should produce spectrally smooth broadband white light, approximating daylight. Spectrally "spiky" spectra can produce problems.
- Color correction software that can recognize each color in an image of the reference color chart and create a calibration profile (HSL Preset file, DNG or ICC profile, or similar), which can be used to color calibrate an image of an object photographed under the same conditions as the reference color chart. Color correction software that does not save calibration files should embed the calibrated RGB values in the image and export it as an sRGB image.

Desirable equipment:

- Digital color camera capable of exporting RAW image files, and the ability to perform an in-camera white balance. The camera should be flat-field corrected to within 2%.
- A RAW file decoder/converter which is able to import RAW images and export them as ≥ 12 -bit TIF or DNG format. Commercial software (e.g. Adobe camera RAW, Capture One, Phocus, etc...) is available, as well as open source software (such as Dcraw).
- Software that can import DNG, TIF, or similar images and perform a correction for illumination non-uniformity and white/gray balance.
- It is recommended that the color correction software provide ability to create ICC profiles. Commercial ICC-aware viewing software is available from several companies, in addition to free software (e.g Irfanview and GIMP).

Procedure:

Image capture

1. Setup up the illumination and background for photographing the object of interest. The background should be a uniform matte color, ideally a gray with 20% reflectance. The camera field of view, shall be adjusted so that it does not extend beyond the gray background. This field of view should be fixed for all photographs.
2. The light source should produce uniform diffuse hemispherical illumination over the field of view, with special attention paid to the lighting uniformity over the image area where colors will be evaluated. This will minimize glare, specular reflections and errors arising from lighting non-uniformity. Examples of diffuse lighting configurations are given in Figure 1.



Figure 1. Example of diffuse lighting setups using commercial softbox lighting (left), or a homemade lightbox with diffuse walls (right).

3. The object of interest and/or reference color chart will define the image region of interest (ROI). For the side-by-side method, the ROI is defined by the object of interest and the color chart placed adjacent to it. In the sequential method, the ROI is defined by the object of interest or the color chart, whichever is larger. Place a uniform diffuse (ideally 20% reflectance) target in the image plane at the ROI. If the gray target is large enough to fill the entire ROI, then it may be used to compensate for illumination non-uniformity during the image post-processing.
4. Position the camera in front of the gray reference and align the camera so that its optical axis is centered on the gray reference and perpendicular to it. The image ROI should be contained within about half the field of view of the camera. If the sequential method is used, it is best to use a tripod, or similar mechanism, to hold the camera stationary for the remainder of the photographs. If the side-by-side method is used, then a fixture similar to that shown in Figure 2 can be used. The side-by-side method is preferred if the illumination is not stable.
5. Use the in-camera white balance function to determine the proper white balance for this lighting condition, and maintain this white balance setting for all subsequent photographs. Some cameras have a Preset Manual or Custom white balance mode to

obtain and hold that white balance setting. Omit this step if the camera does not have in-camera white balance capability.



Figure 2. Example fixture used for the side-by-side image capture method.

6. Capture the image of the gray reference in the ROI. If the illuminance is not uniform in the ROI to within 5%, an illumination non-uniformity correction should be applied in the image post-processing. This correction is only valid if the camera setting and lighting conditions are held constant.
7. Place the reference color test chart in the focus plane of the ROI, so that the camera field of view captures all of the colors in the chart. For the sequential method, the optical axis of the camera should be centered on the chart and perpendicular to it. For the side-by-side method, the edge of the color chart is positioned near the center of the camera image (see Figure 3). Photographic test charts (such as ColorChecker SG can be used, although ideally patches should be matte rather than gloss. Custom charts with patches constructed to be similar to the subject of the photography can also be used (e.g. PANTONE SkinTone™ Guide from X-Rite or Douglas color card may be used for skintones).
8. Set the camera exposure that the lightest color patch in the test chart is approximately 90% of the camera saturation white.
9. For the sequential method, capture the image of the reference color test chart and export the image in RAW file format, if the camera is capable. Where possible, use a “neutral” mode RAW capture setting, which minimizes any camera visual enhancements. Replace the reference color test chart with the first object to be photographed, center in the image, and capture the image of the target object. Repeat the image capture of subsequent objects in turn (see Annex A). Export the images in the same RAW file format. The lighting conditions and camera settings should not be changed. If the camera cannot export RAW files, set the camera to use the highest quality (least compression) image, use low ISO values, and export sRGB images.
10. For the side-by-side method, place the color chart adjacent to the object of interest (see Figure 3) and capture the image using the “neutral” mode RAW capture setting. Export the image in the RAW file format if possible. Replace the first object of interest with other objects in sequence at the same focus plane. The lighting conditions and camera settings should be unchanged. If the camera cannot export RAW files, set the camera to

use the highest quality (least compression) image, use low ISO values, and export sRGB images.



Figure 3. Example alignment of the side-by-side image capture method.

Color correction

1. For RAW files, use a RAW image converter/decoder to extract the image information in all files and save them in a standard image format (e.g. ≥ 12 -bit color TIF, DNG, or similar files). The file should include the desired white balance.
2. If an illumination non-uniformity correction is deemed necessary, apply the uniformity correction to all reference color chart and object images.
3. Open the image of the reference color chart (for the sequential or side-by-side method). Use the program to ensure that the gray levels are scaled correctly. The graylevel scaling will depend on the reference color chart used. However, it is common to use a reference color chart where the whitest color patch is set to an exposure of 90%, or RGB= 230, 230, 230 for 8-bit RGB color images. Then the darkest patch is set to an exposure of 4%, or RGB= 10, 10, 10. If the black patch is below this level, then use the current setting or reshoot the photograph with brighter illumination. For the sequential method, the graylevel scaling applied to the reference color chart is also applied to all object images taken under the same shoot conditions.
4. The color-correction software should automatically find the centers of each color patch of the graylevel-scaled reference color chart image, and create an HSL Preset or color calibration profile (DNG, ICC profile, or similar) based on the known color values of the reference chart. It is recommended that ICC profiles also be created, if it is not already the primary color correction pathway.
5. For the side-by-side method, apply the HSL Preset or color calibration profile to the image and save the new color-corrected image in the desired format (e.g. a high quality TIF file). Repeat the graylevel scaling and color-correction for each side-by-side image. An example of a color-corrected image is shown in Figure 4.



Figure 4: Example of color-corrected image using Figure 3 following the side-by-side method.

6. For the sequential method, import the other photographed objects of interest into the image editing program that is capable of using HSL Presets or color calibration profiles. Apply the HSL Preset or color calibration profile to each image and save the new color-corrected image in the desired format (e.g. a high quality TIF file).

Acknowledement:

The authors would like to thank Yves Vander Haeghen and Dienst ICT at Universitair Ziekenhuis Gent for sharing the figures used in this article.

Annex A

Flowchart of Camera Image Capture and Color Correction Workflow

