TECHNICAL REPORT

ISO/TR 19263-1

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Photography — Archiving systems —

Part 1: Best practices for digital image capture of cultural heritage material

Photographie — Systèmes d'archivage —

Partie 1: Meilleures pratiques pour la capture d'images numériques du matériel de patrimoine culturel

Reference number
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3 Image quality levels

Image analysis of a technical target results in an array of values. A core element of 19264-1 is the use of aims and tolerances to provide valuable insight into image quality. These aims and tolerances have been derived via extensive testing and feedback from cultural heritage imaging users and program managers.

ISO 19264-1 defines three image quality levels presented as a matrix. It is important to note that these quality levels are not provided for any specific use case or category of artwork therefore reaching the highest imaging quality threshold for all categories is not a universal requirement. The quality levels are meant to provide users with a reference to gauge relative image quality and to help establish workflow baselines. End users, user communities, or institutions may refer to the 19264-1 quality level matrix as needed to address different object types, to document and share results or to specify image quality requirements as part of contractual agreements with outside digitization vendors. Program managers may choose to configure and maintain systems that exceed the tolerance definition matrix defined in ISO 19264-1. It is important to document any site or project specific quality aims.

Please refer to the image quality table in ISO 19264-1.

4 Basic principles of image capture and processing

4.1 Overview

In order to record an original digital imaging systems generally follow the steps outlined in the flow diagram shown in Figure 9 which illustrates a typical array sensor device.

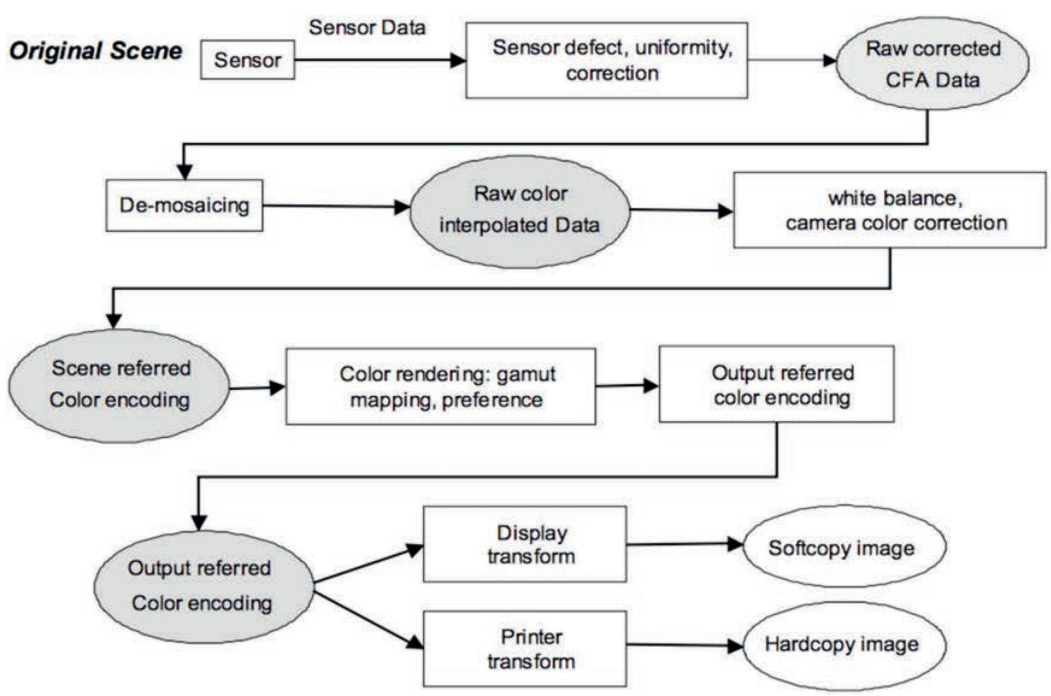


Figure 8 — Typical array sensor device

The reflected, or transmitted light from the object is collected by the optics and detected by an image sensor. The detected data may then be processed for sensor defects and exposure uniformity. If the imaging system used a colour filter array (CFA), the result is an encoded data array corresponding to a spatial pattern of repeated, e.g. red, green and blue, signals. At this point these raw data constitute the first form of 'raw' recorded image, the raw corrected CFA data.

The next step in a typical processing path is the generation of a fully populated three-colour image array. Propriety algorithms, aimed at minimizing colour artefacts, can be applied here. This de-mosaicing operation is the interpolation of the single-record array to a 'raw' interpolated red, green and blue data set. While de-mosaicing algorithms have improved over time, reproduction of certain originals with halftones, etchings and other materials with high frequency visual patterns can suffer from colour Moire artefacts. Moire is defined as a spatial beat phenomenon generated by the modulation of numerous spatial frequencies. Moire artefacts can impact both luminance and chrominance. Line scanners, and multi-shot sensor systems minimize the occurrence of colour Moire artefacts as de-mosaicing is not necessary in these imaging systems.

White-balance, and matrix colour-correction operations are usually applied next. The result is an image data set that is in a scene-referred colour encoding.

The final step in the image processing chain is the rendering, usually for display. The result is a finished image data array in an output-referred colour encoding. This step may be a simple colour-space transformation, but can also include choices for gamut mapping and colour preference.

While the above steps are common in colour image acquisition systems, specific implementation details will vary. Understanding the signal (colour) encoding of a raw image is as important as agreement on a particular file format.

4.2 Scene referred and output referred image states

The terms scene referred and output referred are essential to understand best practice for artwork digitization. ISO 19264-1 employs objective methods to help create images that refer to the original scene or object, in other words: a scene referred image. While scanners are typically engineered to provide a scene-referred response, the majority of commercially available imaging systems are engineered to deliver finished output referred images optimized for "pleasing" renditions. Unfortunately each manufacturer and observer may have different subjective opinions about what is pleasing as opposed to what is accurate. A scene-referred image can be repurposed and reformatted to any media as it contains information traceable back to the original object. When a scene-referred image is converted (via ICC or other colour conversion) or visually edited and optimized for reproduction to a specific medium or device, it becomes output-referred.

4.3 User controls and readouts

4.3.1 General

Digital imaging systems (cameras or scanners) and related control software should provide users necessary access to controls relevant to ISO 19264-1 system optimization. If an imaging system limits access to critical controls and only offers output referred or "factory" image processing functionality, image quality may suffer and users may be unable to configure systems to meet defined quality criteria. If an imaging system does not offer appropriate user controls and readouts the application of ISO 19264-1 may be limited to imaging system performance evaluation and imaging system performance monitoring only, see ISO/TR 17321-3.

4.3.2 Colour Processing Controls

The aim of the colour processing for ISO 19264-1 is to produce accurate scene colourimetry, with the scene adopted white chromatically adapted to the chromaticity of the image encoding adopted white. ISO 17321-1 specifies camera characterization metrology. ISO/TR 17321-2 provides considerations for determining scene analysis transforms. Cameras and scanners should fully support custom user characterization methods such as ICC colour profiles (ISO 15076-1), or DNG digital negative profiles (DCP). Users should be able to select any valid working colour space, destination colour space, custom generated input colour profiles and should be able to disable any factory or proprietary colour rendering functions (untagged). Colour encoding should be of sufficient gamut to encompass the gamut of the original.

4.3.3 Exposure readouts

The display of scene-referred image values converted to CIE *L**a*b** values in the imaging system histogram is preferred. If an imaging system is not able to display scene referred *L**a*b** values, RGB values are acceptable as long as they are clearly defined i.e. source or output encoding, see ISO/TR 17321-3.

4.3.4 Raw processor readouts and controls

If raw image processing software is part of the imaging workflow, the software should be able to read/display scene referred data and have the ability to disable output rendering and should also honor recorded scene adopted white chromaticity (see 4.3.2), User readouts and representation of exposure should operate as described in 4.3.3, see also ISO/TR 17321-3.

4.3.5 Other user controls

The ability for users to create, modify or disable image enhancement functions is helpful when using ISO 19264-1 for imaging system performance optimization. User access to generate custom flat-field corrections and lens corrections can help improve uniformity and minimize geometric distortion when using DSC systems. For scanners and turnkey systems these corrections may not be necessary. Image sharpening and other enhancements require careful attention and are generally discouraged. If and when modifications are made to user controls, for imaging system performance optimization, adjustments need to be documented.

4.3.6 Unwanted data modification

Imaging systems increasingly rely on proprietary image enhancement technologies. In some cases these enhancements can improve ISO 19264-1 results. For example: a DCS or Scanner may employ preset corrections for uniformity (vignetting correction) or geometric distortion, however other enhancements can cause problems. Variable or local image processing enhancements such as near neutral colour optimization, local or single colour improvements or local contrast optimization functions must be avoided. Ideally imaging systems that employ these enhancements should allow the user to disable the functions.

4.4 Master images and derivatives

4.4.1 General

Once an imaging system has been configured to meet the quality criteria as outlined in ISO 19264-1 the resulting images are typically saved as 8 bit or 16 bit RGB Tiff files. Tiff files should include either an embedded device ICC profile, or should be rendered to a standard RGB encoding space with sufficient colour gamut to contain the colour gamut of the originals being digitized. While not a part of ISO 19262 terminology, it is common to refer to these images as master image files.

Any number of derivatives may be created from the master image. A common derivative would be a rendition that is typically down sampled, converted to an appropriate output referred colour encoding space (sRGB) in a JPEG compressed file format. Another derivative may be a set of thumbnail or preview images for a DAM, CMS or other information system. It is important to note that in order to display correctly, careful attention should be given to the proper use of embedded ICC colour profiles and colour management configuration through the entire workflow including web browsers and mobile devices.

4.4.2 Raw image files

A raw image file is often the starting point in the imaging process, and is typically the source for rendition to an image master Tiff image that can be analysed using ISO 19264-1. Raw image data and raw

5 Imaging system setup and calibration

5.1 General

Configuring and validating a DSC or scanner system to meet the ISO 19264-1 specification generally follows the same procedures and begins with establishing correct exposure, tonal response and colour followed by analysis of an ISO 19264-1 compliant test target. Each camera or scanner control software presents different user interface and readout dialogues therefore the process has been generalized to encompass the key elements of configuring any digital camera system. Refer to manufacturer documentation or qualified ISO 19264-1 support professionals for specific recommendations. See 4.3 for relevant system configuration options.

5.2 Position camera system

— The DSC should be mounted to a stable tripod, studio stand, copy stand or other rigid support.

— The DSC should be placed to fit the required colour chart and or technical targets within the live image area. The optical axis of the camera should be positioned normal to the test target(s)

5.3 Establish uniformity-even illumination

5.3.1 General

Lighting should be placed at angles between 30° and no greater than 45° to the normal of the centre of the target area being imaged. Lighting and colour temperature should be approximately 5 000 K, and full spectrum (e.g. Xenon flash). Tungsten, High Frequency Fluorescent, HMI, HID and LED sources can optionally be used. A light source needs to carefully evaluated and relatively full spectrum. CRI in this case can be misleading and mixing lights of different types or ages can adversely impact colour uniformity. When selecting light sources it is important to consider best practice in conservation in terms of light exposure to original artworks.

Light sources should be generally placed no closer than approximately 2× the diagonal dimension of the area being imaged and the light source diameter should be no larger than 1,5× the diagonal dimension of the area being imaged. If the physical dimension of light sources are larger than 1,5× the diagonal of the area being imaged it is important to minimize glare by adjusting lighting distance and or lighting angle.

The white backside of the ISO 19264-1 target can be utilized to help verify initial uniformity. Any spectrally neutral smooth surface with an L^* value of 95 to 75 can be used to establish illumination uniformity. See ISO 19264-1 for L^* tolerances.

5.3.2 Optional flat-fielding

If DSC and or host control software support flat-fielding, this function can be employed to optimize results. It is critical to note that this functionality is directly tied to camera position, aperture, and lighting position. Improper use of flat-fielding can negatively impact image quality. Ideally every attempt should be made to achieve a uniform field without any additional manipulation. Flat-fielding implementation varies. Preferably flat-fielding should adjust pixel sensitivity and not simply via post-capture data manipulation. DSC and or host control software flat-fielding should be implemented in such a way that the function can be reversible. Care should be taken when flat-fielding to ensure the scan area and target used are clean. Surface imperfections and dust could negatively impact subsequent images. For digital cameras it is best to defocus the system when capturing the flat-fielding reference.

5.4 Establish exposure

Establishing exposure for DSC systems is difficult to summarize due to a current lack of standardization of UI value readouts however the following generalized steps based upon the use of grayscale targets and tolerances have proven to be reliable.

— Configure DSC or host control software to disable tone reproduction curve adjustments if possible. Note: some systems offer a “linear” or “reproduction” tone curve setting.

— Disable camera/host colour processing (to the extent possible).

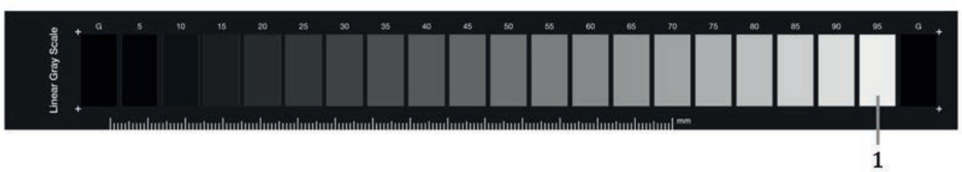
— (RIMM RGB). If RIMM RGB or suitable scene referred encoding is not an available option, the default colour encoding should be at large enough colour gamut to encompass the colour chart utilized for profile creation.

— Make sure that all image adjustments are set to default or null.

— Disable any automatic gain (analog or digital) or adaptive tone reproduction.

— The procedure for ensuring achromatic whites, grays, and blacks (white balancing) should be fixed using a known spectrally neutral chart value. The chart value for neutralization should be between *L**50 and *L**95.

— Place a linear grayscale (or any target with an *L**95 spectrally neutral patch) in the centre of the image area and make a test exposure. Adjust the system exposure (via adjustment of light output, distance and or camera settings) until a value of *L**95 is achieved (see Annex A for RGB values if the system does not support *L** readouts).



Key

1 95*L**

Figure 10 — Linear gray scale for establishing exposure

5.5 Establish tone reproduction curve (OECF)

— Using the linear grayscale verify the remaining values along the gray scale are within tolerance(s) Note: if tolerances for darker values do not match aims, it may be necessary to adjust lighting angle and or tone curve/histogram controls in host control software. If adjustments are necessary, these adjustments should be saved as a user preset

— All user settings should be recorded

5.6 Create an ICC colour profile

ICC Colour profiles can be created using integrated camera profiling functions or external third-party profiling applications. The X Rite ColourChecker® Digital SG (DCSG) colour chart is often along with appropriate chart reference data are often used for this purpose.

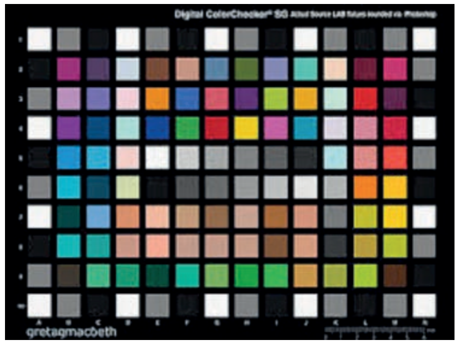


Figure 11 — ICC colour profile

— After having established correct chart illumination and exposure, capture the colour chart. If your software does not support built in ICC colour profiling export the file as a 16bit RGB Tiff in a colour encoding space that is larger gamut than the colour chart you wish to utilize for profiling (Note it is possible to characterize cameras using raw image data, but the process can become complicated due to a lack of standardization for raw data and its interpretation).

— Using any software capable of creating ICC input profiles, follow the manufacturer's steps to generate an ICC profile.

— After loading the ICC input profile, select the profile in the DSC or host control software.

— Re-Verify Neutral Balance, Exposure, and Tone Reproduction (OECF).

— Capture a new chart image and re-check neutral balance, exposure, and tone reproduction. Export the file making sure to embed the custom ICC device profile or working colour encoding space.

5.7 Analyse colour and tone

The image of the colour chart can be compared to the chart reference data manually or via open source or commercial analysis tools. For colour evaluation the ΔE 2000 formula is recommended using a SL 1 in the calculations*. The ΔE 2000 colour difference formula as published was not specifically engineered for scene referred imaging analysis and assumes a non linear transform for lightness that is not appropriate for calculating ΔE values for scene referred imaging applications. Specifically, without modification, the ΔE calculation will report inaccurate ΔE values even when source L^* target values perfectly match L^* values in an image. Ensure that the software you are utilizing for image analysis supports this particular ΔE calculation method.

When configuring an imaging system it is a good idea to validate the capture of a colour chart to its reference data as well as comparing spectral measurements of sample artworks with their representations. It's essential that the chart and reference data are verified or known.

6 Application of image quality analysis

6.1 Selection of imaging systems: preflighting equipment or vendors

The best time to implement an imaging strategy is after your project scope has been clearly defined and the collection has been assessed. If the collection goals are appropriate and the size of original work is known, one can evaluate equipment strictly based upon technical performance criteria and by analysing test targets. Due to the complexity of imaging systems it is common for imaging systems to easily pass certain criteria while failing other criteria, the results of ISO 19264 analyses will help identify and resolve problems. For example: A failure to pass illumination uniformity aims can be traced to the incorrect positioning of a light source. Failure in a single chart MTF region may reveal that the imaging system plane is not parallel to the artwork plane. If an imaging system does not pass certain

