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

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Photography — Archiving systems —

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

1 Scope

This document specifies how to perform quality analysis of imaging systems (e.g. flatbed scanners, planetary scanners, or digital still cameras) used for digitization of reflective two-dimensional originals.

Original materials include but are not limited to books, textual documents, drawings, prints, photographs, and paintings. Certain types of two-dimensional materials with complex surface geometry and or highly reflective surface elements require special illumination techniques that can fall outside the scope of this document.

NOTE ISO/TS 19264-2 will address transmissive materials.

2 Analysis of image quality

2.1 General

In order to analyse imaging system quality ISO 19264-1 specifies a technical target (ISO 19264-1 target) designed to incorporate multiple technical features for the measurement of key imaging characteristics from a single image. Calculations are performed via software dedicated to ISO 19264-1 target analysis.

2.2 Image quality characteristics

Image technical analysis involves a number of interrelated measurement steps, typically the analysis process begins with validating white balance and tone reproduction followed by additional calculation steps as listed below. When all measurements are within a set of defined tolerances, an imaging system meets a defined quality level. Resolution and geometry are analysed after first analysing core image quality elements.

— **White Balance**: adjustment of electronic still picture colour channel gains or image processing so that radiation with relative spectral power distribution equal to that of the scene illumination source is rendered as a visual neutral.

— **Tone Reproduction Curve (TRC)**: curve graphically describing the relationship between the input tones and the output tones in an imaging process.

— **Gain Modulation** (highlights/other patches): variation of the gain over the signal level.

— **Noise**: unwanted variations in the response of an imaging system.

— **Dynamic Range**: the difference, over a given period of time, between maximum and minimum signal levels, expressed in decibels, contrast ratios or f-stops.

— **Banding**: unwanted stripes or bands that occur in a digital image.

— **Defect Pixels**: pixel or subpixel that operates in a way other than the one in which it is driven.

— **Colour Accuracy**: ability of an imaging system to reproduce the colours of some intended object, as specified using some colour difference metric.

— **Sampling Rate** (difference between claimed and obtained): number of samples per unit of time, angle, revolutions or other mechanical, independent variable for uniformly sampled data.

— **Resolution (limiting)**: measure of the ability of a camera system, or a component of a camera system, to depict picture detail.

— **Sharpening**: amplification of the SFR by means of image processing to achieve sharper appearing images. Also, a class of image processing operations that enhances the contrast of selective spatial frequencies, usually visually important ones.

— **MTF 50**: the modulation transfer function is, a measure of the transfer of modulation (or contrast) from the subject to the image and is used to measure spatial frequency response (SFR). In other words, it measures how faithfully the imaging system reproduces (or transfers) detail from the target to the digital image. MTF50 refers to that spatial frequency (expressed in lines per mm) at which the image retains 50 % of the test target's contrast, see ISO 12233.

— **Illumination non-uniformity** (target size related): application of visible radiation (light) to an object.

— **Colour mis-registration**: colour-to-colour spatial dislocation of otherwise spatially coincident colour features of an imaged object.

— **Distortion**: displacement from the ideal shape of a subject (lying on a plane parallel to the image plane) in the recorded image.

— **Reproduction scale**: ratio of the size of an object in a digital image and the size of the original object.

2.3 ISO 19264 Test chart technical features

The ISO 19264-1 target is defined in ISO 19264-1:—, Annex A. Individual chart features are reproduced here to illustrate functionality. An ISO compliant target should contain all of the technical features. Additional targets are utilized for characterizing imaging system colour and tone.

2.4 Grid and gray/white features

2.4.1 General

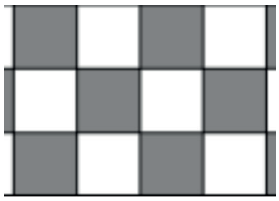


Figure 1 — Example of grid and gray/white features

Gray/white grids are used for analysing illumination non-uniformity and distortion. Illumination non-uniformity is similar to white balance, but applies to illumination at all tonal levels across the entire imaging field and can be adversely affected by the introduction of non-image forming light and or lens falloff. Distortion is often corrected digitally, but doing so recalculates each pixel location in an image, this may negatively influence image resolution but may also contribute to an overall improvement in image reproduction accuracy. Illumination-non uniformity results are expressed as ΔL^* differences between the maximum and minimum L^* values.

2.4.2 Running scale features (cm and inches)

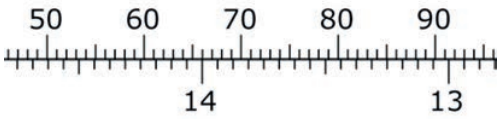


Figure 2 — Example of running scale

Scales are used to determine X and Y resolution, and to test for constant movement (scanners, stitching systems).

NOTE This measured function identifies the actual imaged values in both x and y directions, assuring scale integrity of the images

2.4.3 Grayscale and running gray/white/black bar features

Figure 3 — Example of grayscale and running gray/white/black bar features

The grayscale and running gray/white bars are used to determine OECF (tone recording), gain modulation, noise, and signal to noise ratio

Imaging systems should convert the tone values in the original scene to digital values; this technical term is OECF (Opto-Electronic Conversion Function). Validation of the correct selection of these parameters and appropriate representation of the digital information for the selected parameters is a critical function of image quality analysis.

Gain modulation refers to the variation of the gain (distribution of tonal values) over the signal level and is a critical factor in reproduction imaging and colour accuracy. Reported as ΔL^*values. The smaller the deviation between the L^* of the patches in the reference target and the L^* values represented by the digital code values the more accurate the tone reproduction.

Noise is generally the digital equivalent of film grain, and presents itself as pixel-to-pixel fluctuations often seen in deep shadow areas. Noise has the effect of reducing the overall perceived smooth tonality of an image. Noise can also take a one-dimensional form called banding or streaking.

Signal to noise ratio is the ratio of the incremental output signal to the root mean square (rms) noise level, at a particular signal level.

2.4.4 Colour patch features

Figure 4 — Example of colour patch features

The colour patch element is used for determination of colour accuracy, test of the colour space, validation of ICC profiles, and survey of colour variation across the scanning area.

Results are reported in ΔE 2000* values in the form of a table for each individual patch together with the result for the mean and the max value for all patches. It is sufficient to report the mean and the

max value only. Observation of the best 90 % can be helpful to help identify outlying data but is not mandatory.

Δ*E* 2000* values are calculated using a linear (SL=1) formula (see ISO 19264-1).

2.4.5 MTF measurement features

Figure 5 — Example of MTF measurement features

The MTF element enables measurement of sampling resolution according to ISO 16067-1 (up to 1200 PPI max.).

Resolution (Limiting) is the highest frequency (spacing) that image detail can be distinguished. Scanners and cameras may claim very high resolutions that are unachievable due to design limitations of the total imaging system. This measure identifies the actual achieved resolution and should not be confused or considered equivalent to sampling rate.

This chart element also helps calculate sampling efficiency, and provides for visual resolution check up to 18 lp/mm. Sampling efficiency is also calculated using the MTF. Example-if the object captured is 10 in long and the sensor has 4000 pixel features capturing the 10 inches, the sampling rate is 400 pixels/in. Most imaging systems cannot achieve 100 % sampling efficiency. An accurate sampling rate is essential to knowing the size of the original object.

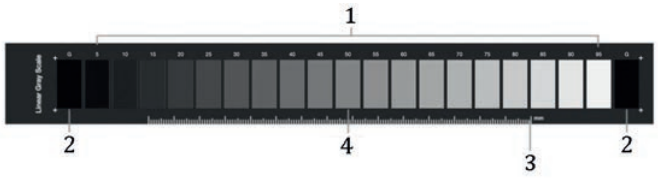
2.4.6 Additional ISO 19264 target features/reference data

Additional chart areas may be designated for labelling, additional test patterns or chart features and manufacturing information. Chart Reference Data are typically custom measured and delivered from test chart vendors in text table form to be used as a reference for calculations. Chart reference data sets and measurement methods should be documented.

2.5 Additional targets

In addition to the ISO 19264-1 target other targets may be used to characterize the imaging system. The following targets aid in the characterization of imaging systems.

2.6 Linear grayscale



Key

1 semi gloss values (5L* to 95*L)
2 gloss black (4L*)
3 measurement scale, in mm
4 perceptual middle value (50L*)

Figure 6 — Example of linear grayscale

A linear grayscale is useful for configuration and verification of tone reproduction (OECF) and gain modulation. The target incorporates semi-gloss spectrally neutral pigments equally spaced in 5L* steps from L*5 to L*95 with additional gloss black patches. The gloss patches extend the dynamic range and are used to visually assess lighting reflections and glare from improper lighting geometry.

2.6.1 DCSG colour chart

Figure 7 — Example of DCSG colour chart

The X Rite Colour Checker® Digital SG (DCSG) colour chart is useful for colour calibration (device characterization). Colour charts may vary in terms of substrate, gloss factor, colour gamut and number of patches. A colour chart that closely matches the surface quality and colour gamut of the original artwork may be utilized.

2.6.2 Limitations of Chart Based Imaging System Analysis

Being that ISO 19264 is based upon analysis of test charts with technical patterns and reference values there are inherent limitations that need to be considered. Fabrication of technical targets varies over time, and targets have a finite life span. Baseline data used to define technical targets (chart reference data) can also vary between users and vendors. Vendors may improperly implement the analysis methods outlined in ISO 19264. Beyond these possible variables, there are variables in the surface qualities of original artworks, capture illuminants and sensors that limit the ability to ensure an exact colourimetric or perceptual match.

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.

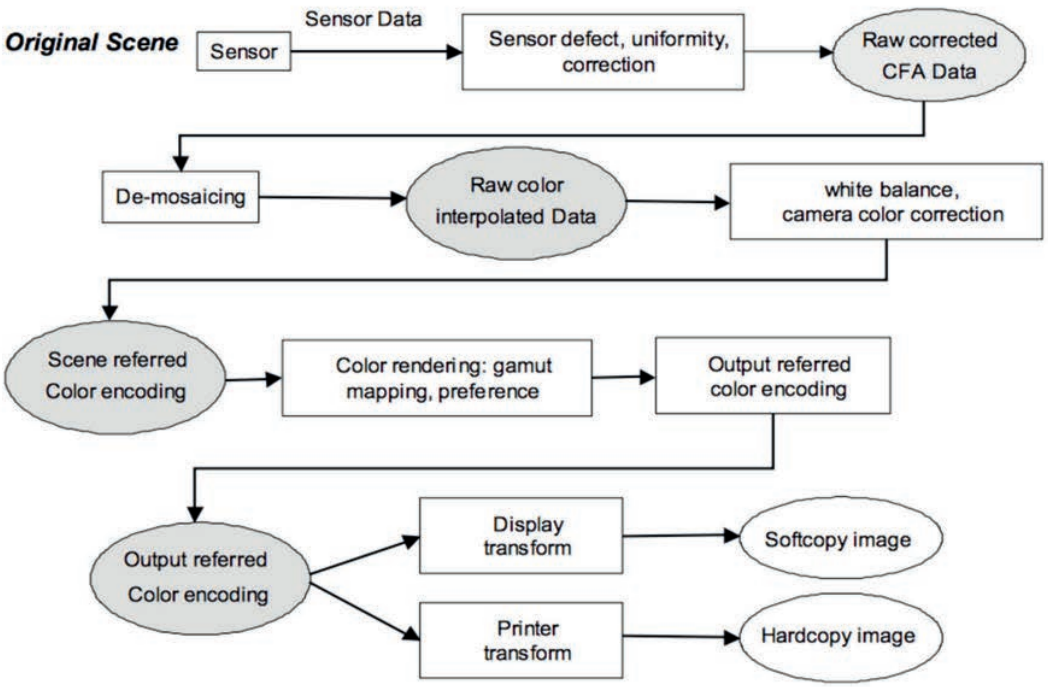


Figure 8 — Typical array sensor device

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