TECHNICAL REPORT

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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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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 42, *Photography*.

Introduction

Today digitization programs need to satisfy the demands of an interconnected dynamic user community. A digitized image can be repurposed across any number of systems and therefore needs to be well defined, technically robust and media agnostic. The digital image of an original is intended to satisfy multiple uses including access, archiving, research, conservation, education, marketing, social media, reproduction and distribution both in print and online.

Intended for organizations, such as cultural heritage institutions, ISO 19264-1 specifies a method for analysing imaging systems where it is important to control the degree of accuracy and to ensure that imaging quality is maintained over time. There are three common applications of ISO 19264-1:

a) imaging system performance evaluation (benchmarking) – used for system development and system selection

b) imaging system performance optimization – used for tailoring the system to a particular job (use case)

c) imaging system performance monitoring – used for controlling that the quality of the system remains consistent and within specifications over time

The purpose of this document is to provide practical guidance on how to apply ISO 19264-1 for cultural heritage imaging of two-dimensional originals. This includes how the image quality analysis is performed, the function of technical target features, and how to adjust/optimize the performance of imaging systems. Additionally this document illustrates how ISO 19264-1 can be used for selection of appropriate imaging systems and how to establish and maintain image quality in digitization workflows.

Annex B provides information related to developing a digitization strategy including assessment of collections, developing a hardware strategy and system selection.

ISO 19262 provides definitions for imaging terminology used in this document and ISO 19264-1.

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

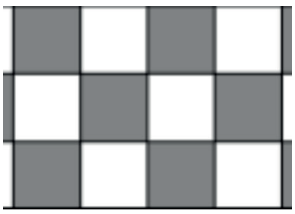


Figure 1 — Example of grid and gray/white features

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)

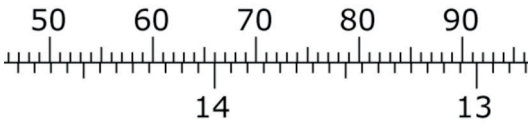


Figure 2 — Example of running scale

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.

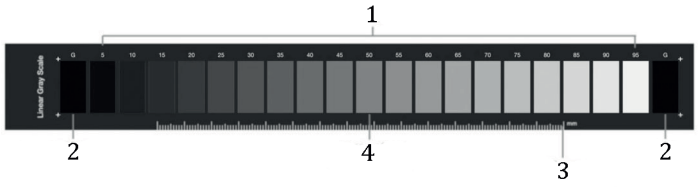
2.4.6 Additional ISO 19264 target features/reference data

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

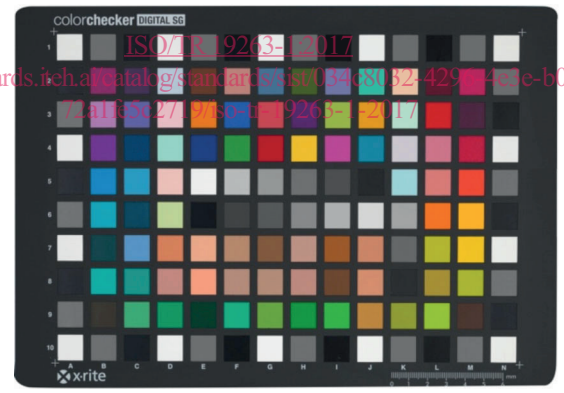


Figure 7 — Example of DCSG colour chart

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.