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Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange —

Part 4:
European Colour Initiative RGB colour image encoding [eciRGB (2008)]

Photographie et technologie graphique — Codages par couleurs étendues pour stockage, manipulation et échange d'image numérique —

Partie 4: Codage d'image en couleurs RGB par initiative de couleur européenne [eciRGB(2008)]

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Contents

Page

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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 42 *Photography*.

This first edition cancels and replaces the first edition (ISO/TS 22028-4:2012), which has been technically revised.

The main changes are as follows:

— this document is released as an International Standard (prior edition was a Technical Specification);

— editorial revisions have been made.

A list of all parts in the ISO 22028 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document has been developed in order to meet the industry need for a complete, fully documented, publicly available definition of an output-referred extended gamut RGB colour image encoding which is optimized for an 8-bit encoding and the conversion of RGB images into offset print colour spaces. Since users have also asked for a 16-bit encoding it has been added to this document as well. This colour image encoding provides a way to represent output-referred images that does not limit the colour gamut to those colours capable of being displayed on a CRT monitor, such as that represented by the sRGB colour encoding, or require the use of negative RGB colorimetry coordinates, such as with extended sRGB colour encodings like bg-sRGB.

An extended colour-gamut colour encoding is particularly desirable for professional photography applications. For example, colours used for company logos may be outside a monitor gamut and would therefore need to be clipped or compressed to a less saturated colour. Similarly, scanned photographic prints that are to be duplicated may contain colours outside a monitor RGB colour-gamut. By using a standard output-referred extended gamut colour image encoding, images containing such colours can be stored, interchanged, manipulated, and later printed, without limiting or distorting the colours of the final output.

The European Colour Initiative (ECI) RGB colour image encoding [eciRGB (2008)] specified in this document meets the needs of these types of applications.

The primaries of eciRGB (2008) (see Annex C, Figures C.1 and C.2) are between Reference Output Medium Metric RGB (ROMM RGB) and sRGB, thereby providing a larger gamut than sRGB, together with lower quantization errors than ROMM RGB. The tone curve has an encoding linear to the L* axis defined in the CIE 1976 (L^*, a^*, b^*) colour space (CIELAB 1976).

This document has been prepared to provide sufficient documentation, consistent with the definitions of ISO 22028-1, to allow the imaging community adequate opportunity for implementation and evaluation of this colour image encoding. Sufficient implementation of, and practical experience in the use of, eciRGB (2008), has led to a revision of the former Technical Specification and its conversion into an International Standard.

The European Colour Initiative owns the copyright on the name eciRGB (2008) and has granted ISO the irrevocable non-exclusive right to use the name for the purpose of this document. A colour encoding named eciRGB was initiated by ECI in 2004. A second version of this encoding with a modified tonal curve was defined in 2008. Because of its importance to the European photographers and graphic arts industry, this document was prepared in order to fully define eciRGB according to ISO 22028-1.

Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange —

Part 4: European Colour Initiative RGB colour image encoding [eciRGB (2008)]

1 Scope

This document defines an extended colour-gamut output-referred RGB colour image encoding designated as European Colour Initiative RGB [eciRGB (2008)]. Digital images encoded using eciRGB (2008) can be manipulated, stored, transmitted, displayed, or printed by digital still picture imaging systems. Two precision levels are defined, using 8 bits/channel and 16 bits/channel.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3664:2009, *Graphic technology and photography — Viewing conditions*

ISO/CIE 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO 22028-1:2016, *Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange — Part 1: Architecture and requirements*

CIE Publication 15, *Colorimetry*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
adapted white
colour stimulus that an observer who is adapted to the viewing environment would judge to be perfectly achromatic and to have a luminance factor of unity, i.e. absolute colorimetric coordinates that an observer would consider to be a perfect white diffuser

Note 1 to entry: The adapted white can vary within a scene.

3.2
additive RGB colour space
colorimetric colour space having three colour primaries (generally red, green and blue) such that CIE XYZ tristimulus values can be determined from the RGB colour space values by forming a weighted combination of the CIE XYZ tristimulus values for the individual colour primaries, where the weights are proportional to the radiometrically linear colour space values for the corresponding colour primaries

Note 1 to entry: A simple linear 3 × 3 matrix transformation can be used to transform between CIE XYZ tristimulus values and the radiometrically linear colour space values for an additive RGB colour space.

Note 2 to entry: Additive RGB colour spaces are defined by specifying the CIE chromaticity values for a set of additive RGB primaries and a colour space white point, together with a colour component transfer function.

3.3
colour component transfer function
single variable, monotonic mathematical function applied individually to one or more colour channels of a colour space

Note 1 to entry: Colour component transfer functions are frequently used to account for the nonlinear response of a reference device and/or to improve the visual uniformity of a colour space.

Note 2 to entry: Generally, colour component transfer functions will be nonlinear functions such as a power-law (i.e. "gamma") function or a logarithmic function. However, in some cases a linear colour component transfer function can be used.

3.4
colour encoding
generic term for a quantized digital encoding of a colour space, encompassing both colour space encodings and colour image encodings

3.5
colour gamut
solid in a colour space, consisting of all those colours that are either: present in a specific scene, artwork, photograph, photomechanical, or other reproduction; or capable of being created using a particular output device and/or medium

3.6
colour image encoding
digital encoding of the colour values for a digital image, including the specification of a colour space encoding, together with any information necessary to properly interpret the colour values such as the image state, the intended image viewing environment and the reference medium

Note 1 to entry: In some cases, the intended image viewing environment will be explicitly defined for the colour image encoding. In other cases, the intended image viewing environment can be specified on an image-by-image basis using metadata associated with the digital image.

Note 2 to entry: Some colour image encodings will indicate particular reference medium characteristics, such as a reflection print with a specified density range. In other cases, the reference medium will be not applicable, such as with a scene-referred colour image encoding, or will be specified using image metadata.

Note 3 to entry: Colour image encodings are not limited to pictorial digital images that originate from an original scene, but are also applicable to digital images with content such as text, line art, vector graphics and other forms of original artwork.

3.7
colour rendering
mapping of image data representing the colour-space coordinates of the elements of a scene to output-referred image data representing the colour-space coordinates of the elements of a reproduction

Note 1 to entry: Colour rendering generally consists of one or more of the following: compensating for differences in the input and output viewing conditions; tone scale and gamut mapping to map the scene colours onto the dynamic range and *colour gamut* (3.5) of the reproduction; and applying preference adjustments.

3.8
colour space
geometric representation of colours in space, usually of three dimensions

[SOURCE: CIE Publication 17.4, 845-03-25]

3.9
colour space encoding
digital encoding of a *colour space* (3.8), including the specification of a digital encoding method, and a *colour space* (3.8) value range

Note 1 to entry: Multiple colour space encodings can be defined based on a single colour space where the different colour space encodings have different digital encoding methods and/or colour space value ranges. (For example, 8-bit sRGB and 10-bit e-sRGB are different colour space encodings based on a particular RGB colour space.)

3.10
colour space white point
colour stimulus to which *colour space* (3.8) values are normalized

Note 1 to entry: It is not necessary that the colour space white point correspond to the assumed adapted white point and/or the reference medium white point for a colour image encoding.

3.11
extended gamut
colour gamut (3.5) extending outside that of the standard sRGB CRT display as defined by IEC 61966-2-1

3.12
gamut mapping
mapping of the colour-space coordinates of the elements of a source image to colour-space coordinates of the elements of a reproduction to compensate for differences in the source and output medium *colour gamut* (3.5) capability

Note 1 to entry: The term “gamut mapping” is somewhat more restrictive than the term “colour rendering” because gamut mapping is performed on colorimetry that has already been adjusted to compensate for viewing condition differences and viewer preferences, although these processing operations are frequently combined in reproduction and preferred reproduction models.

3.13
ICC profile
International Colour Consortium file format, used to store transforms from one *colour encoding* (3.4) to another, e.g. from device colour coordinates to profile connection space, as part of a colour management system

Note 1 to entry: See Annex A for more information.

3.14
image state
attribute of a *colour image encoding* (3.6) indicating the rendering state of the image data

Note 1 to entry: The primary image states defined in this document are the scene-referred image state, the original-referred image state and the output-referred image state. See Annex A for more information.

3.15
luminance factor
ratio of the luminance of the surface element in the given direction to that of a perfect reflecting or transmitting diffuser identically illuminated

[SOURCE: CIE Publication 17.4, 845-04-69]

3.16
medium black point
neutral colour with the lowest luminance that can be produced by an imaging medium in normal use, measured using the specified measurement geometry

Note 1 to entry: It is generally desirable to specify a medium black point that has the same chromaticity as the medium white point.

3.17
medium white point
neutral colour with the highest luminance that can be produced by an imaging medium in normal use, measured using the specified measurement geometry

3.18
output-referred image state
image state (3.14) associated with image data that represents the colour-space coordinates of the elements of an image that has undergone *colour rendering* (3.7) appropriate for a specified real or virtual output device and viewing conditions

Note 1 to entry: When the phrase "output-referred" is used as a qualifier to an object, it implies that the object is in an output-referred image state. For example, output-referred image data are image data in an output-referred image state.

Note 2 to entry: Output-referred image data are referred to the specified output device and viewing conditions. A single scene can be colour rendered to a variety of output-referred representations depending on the anticipated output viewing conditions, media limitations, and/or artistic intents.

Note 3 to entry: Output-referred image data can become the starting point for a subsequent reproduction process. For example, sRGB output-referred image data are frequently considered to be the starting point for the colour re-rendering performed by a printer designed to receive sRGB image data.

3.19
tristimulus values
amounts of the three reference colour stimuli, in a given trichromatic system, required to match the colour of the stimulus considered

[SOURCE: CIE Publication 17.4, 845-03-22]

3.20
veiling glare
light, reflected from an imaging medium, that has not been modulated by the means used to produce the image

Note 1 to entry: Veiling glare lightens and reduces the contrast of the darker parts of an image.

Note 2 to entry: In CIE 122, the veiling glare of a CRT display is referred to as ambient flare.

3.21
viewing flare
veiling glare (3.20) that is observed in a viewing environment but not accounted for in radiometric measurements made using a prescribed measurement geometry

Note 1 to entry: The viewing flare is expressed as a percentage of the luminance of adapted white.

4 Requirements

4.1 General

European Colour Initiative RGB [eciRGB (2008)] is an extended gamut RGB colour image encoding for representing the colorimetry of display-referred image data in a display-referred image. Scene referred images can be converted into eciRGB (2008) using colour rendering. The output-referred image data

has the intended colour appearance when viewed on a reference colour monitor in a reference viewing environment. The image colorimetry is encoded in terms of an additive RGB colour space associated with a hypothetical additive colour device having a specified set of primaries, no cross-talk between the colour channels and a luminance dynamic range defined by an associated medium black point and medium white point.

The encoding can either be in 8 bits/channel or 16 bits/channel (24 bits/pixel or 48 bits/pixel).

The image colorimetry shall be based on flareless (or instrument flare corrected) colorimetric measurements as described in CIE Publication 15 using the CIE 1931 Standard Colorimetric Observer defined in ISO/CIE 11664-1.

NOTE The intended colour appearance can be reproduced on a physical device in an actual viewing environment, only when the actual viewing environment matches the reference viewing environment. See Annex B for recommended tolerances for viewing eciRGB (2008)-encoded data in an actual viewing environment.

The colour image encoding defined in this document conforms to the requirements defined in ISO 22028-1:2016, Clause 5. To convert images into this encoding, an ICC profile as described in Annex A can be used. For the viewing of an image in the eciRGB (2008), encoding the tolerances described in Annex B apply.

4.2 Reference viewing environment

4.2.1 General

The following reference viewing conditions define the reference viewing environment for the eciRGB (2008) colour image encoding. They shall be based on conditions for appraisal of images displayed on colour monitors as specified in ISO 3664:2009, 4.5. These specifications are applicable for images viewed independently of any form of hardcopy; they are not designed for direct comparison between hardcopy and softcopy.

4.2.2 Ambient illumination

When measured, with the monitor turned off, at the monitor faceplate, the ambient illumination level shall be equal to 32 lx. When measured, with the monitor turned off, in any plane between the monitor and the observer, the ambient illumination level shall be within the range of 16 lx to 64 lx. The ambient illumination shall have the same chromaticity as the white point of the display.

4.2.3 Reference display surround

The area immediately surrounding the displayed image may affect the local state of adaptation of the eye upon viewing the image. This surround shall be a neutral gray, of the same chromaticity as the reference display white point. The surround shall extend at least two degrees from the edge of the image in all directions. Its luminance shall be 20 % of the reference display white point, that is, 32,00 cd/m^2.

NOTE If the monitor is equipped with a hood, the ambient illumination of the extended surround outside the hood can be kept higher than the ambient illumination at the monitor faceplate, possibly enabling the use of a reflective extended surround.

4.2.4 Image size and viewing distance

The normal to the centre of the display faceplate shall be the viewer's direction of gaze. The viewing distance shall be equal to the image diagonal, or longest chord.

4.2.5 Glare

The veiling glare in the reference viewing environment shall be included in the display black point, as would result from measurement of the display from the viewer position in the reference viewing