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Image technology colour management — Evaluating colour transform accuracy in ICC profiles

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Introduction

International Color Consortium (ICC) input and output profiles contain transforms between device data encodings and the ICC Profile Connection Space (PCS). These transforms should provide either an accurate colour match or a pleasing rendering, depending on the chosen rendering intent.

The following guidelines are provided to assist in the evaluation of the colorimetric rendering intent transforms in ICC v4 profiles. Any tolerances provided in this document are for guidance only and may not be suitable for all applications.

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Image technology colour management — Evaluating colour transform accuracy in ICC profiles

1 Scope

This document describes procedures for evaluating the accuracy of colorimetric rendering intents in ICC profiles.

It applies to v4 ICC profiles made according to ISO 15076-1.

It does not apply to subjective tests of ICC profiles, such as for perceptual or saturation rendering intents, and it does not apply to high dynamic range colour media or spaces.

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 15076-1, *Image technology colour management — Architecture, profile format and data structure — Part 1: Based on ICC.1:2010*

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3 Terms, definitions and abbreviated terms

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3.1 Terms and definitions

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

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

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

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

3.1.1
AToB1Tag
structure in an ICC profile that encodes the forward model in media-relative colorimetry

3.1.2
BToA1Tag
structure in an ICC profile that encodes the inverse model in media-relative colorimetry

3.1.3
chromaticAdaptationTag
invertible matrix which converts a CIE XYZ colour, measured using the actual illumination conditions and relative to the actual adopted white, to a CIE XYZ colour relative to the PCS adopted white with complete adaptation

3.1.4
colour lookup table
array of values corresponding to the output of a transform applied to a grid of values which span the input data encoding

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3.1.5
colour management module
computational resource that applies ICC profiles to data encodings

3.1.6
forward model
mathematical model that predicts CIE colorimetry from device encoding values

3.1.7
inverse model
mathematical model that predicts device encoding values from CIE colorimetry

3.1.8
profile connection space
PCS
colour space used to connect source and destination ICC profiles

Note 1 to entry: The full definition of the PCS is given in ISO 15076-1:2010, Annex D.

3.1.9
PCSLAB
CIELAB values calculated from CIE XYZ values that have been uniformly scaled so that X = 0,964 2, Y = 1,0, Z = 0,824 9 for the media white, and encoded as 8-bit or 16-bit integers or as floating point numbers

Note 1 to entry: The full definition of PCSLAB is given in ISO 15076-1.

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3.1.10
rendering intent
style of mapping colour values from one image description to another

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3.2 Abbreviated terms

CIE Commission Internationale de l'éclairage (International Commission on Illumination)

CLUT Colour lookup table (multi-dimensional)

CMM Colour management module

ICC International Color Consortium

PCS Profile connection space

4 Profile evaluation tests

4.1 General

Two types of profile evaluation tests may be performed on the media-relative colorimetric rendering intent (the BToA1Tag and the AToB1Tag) of an ICC profile. These tests apply the transform contained in the profile's BToA1Tag and/or AToB1Tag and compare the results with an appropriate reference.

4.2 Round trip tests

Round trip tests determine the accuracy with which a given rendering intent within a profile is inverted, such that when a PCS value is converted to the device encoding and back to the PCS the difference is minimized. When performing a round trip test, it is essential that the final test is performed on coordinates within the gamut of the encoding, and an initial transform from the device data encoding may be required to achieve this.

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4.3 Device model tests

Device model tests of a profile determine the accuracy of the forward model with which the profile predicts the colorimetry of a given device encoding value, or the accuracy with which the profile predicts the device encoding value that will produce a given colorimetry.

See Annex A for additional information on forward model accuracy.

5 Round trip accuracy

5.1 General

A round trip test of a profile is performed by converting a set of PCS values to the device encoding, using the profile's BToA1Tag, and then back to PCS values using the profile's AToB1Tag.

5.2 Test image

The set of PCS values for the round trip test shall be obtained as follows. A test image such as that defined in ISO 12642-2 is used to provide a sample of the device encoding. This image is converted to PCSLAB using the AToB1Tag of the profile, back to device space using the BToA1Tag, and finally back to PCSLAB using the AToB1Tag. This procedure ensures that only in-gamut colours are used in the round trip accuracy test.

Where possible, a test image should contain different values from those used to derive the AToB1Tag tables and from those used as the input table in the BToA1Tag transform.

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NOTE The differences in PCSLAB values between the first and second set of PCSLAB values obtained in this way are often referred to the "first round trip" accuracy.

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In addition to the test chart defined in ISO 12642, particular applications may require additional test colours representative of the sub-set of the colour gamut of interest to that application. Examples of such sub-sets include additional neutrals and near-neutrals to better evaluate the grey balance of a transform; and colours corresponding to skin colours for images where such colours predominate. In such cases, a user- or vendor-dependent test set may be added. The evaluation report shall state how many test colours and which test image was used in the evaluation.

5.3 Round trip test

The final PCSLAB values obtained in 5.1 are used as the initial values in the round trip test. They are converted to device space using the BToA1Tag, and then back to PCSLAB using the AToB1Tag.

The differences between the initial PCSLAB values and the PCSLAB values after the round trip shall be expressed as median, maximum and 95th percentile values in ΔE_{00}, where the PCSLAB values are scaled to ICC-Absolute colorimetry according to ISO 15076-1. Round-trip colour differences in ΔE_{00} typically are < 1 median and < 2 maximum.

Preview tags are not used for testing round-tripping errors.

NOTE 1 Round trip results are likely to be affected by the device characteristics and the colour management module (CMM) used, as well as the profile. In a comprehensive test, a profile that is to be used in open systems is evaluated using several CMMs, preferably those that will be used in practice.

NOTE 2 The round trip error does not predict the accuracy of the forward or inverse model, but is simply a measure of the inversion accuracy of the profile. It can be used to estimate the inverse model error as described in Clause 6.

NOTE 3 The utility of the round trip error is directly related to the accuracy of the forward model fit. The round trip error is less meaningful if the forward model is poor, for example if there is noise in the training data used to generate it.

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