Consistent Colour Appearance assessment method

CIE TC 8-16, W Craig Revie
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2 Scope

To study and report on sets of reproductions of the same source image that have a consistent colour appearance and are most similar to a reference reproduction, including recommending assessment methods that measure the similarity of reproductions of an image with different colour gamuts, for printed images on substrates with approximately similar characteristics in a fixed viewing environment. Only the effect of colour reproduction on appearance will be considered by this TC and so the assessment will be performed using hard copy or soft copy proofing. To propose a metric which can measure consistency of colour appearance.
CIE TC8-16 Assessment of Consistent Colour Appearance

- Identification of resources
  - Reference images (available to all members of CIE TC8-16 – details on COLLTOOL)
  - Reference print gamuts (see http://www.color.org/resources/r8-13/CCA-gamuts.xalter)
  - Reference display (details from BenQ)
    - Reference proofing system
    - Uniform colour space
- Image preparation
- Viewing conditions
- Psychophysical assessment
- Measurement assessment
Candidate images (ISO 12640 SCID)

ISO12640-2 sRGB SCID

ISO12640-3 CIELAB SCID

ISO12640-4 AdobeRGB SCID
Although not representative of typical imagery, these images may be better than the ISO set for some purposes, for example when it is important to see what is happening in particular parts of the colour gamut.
Candidate images (ISO 12640 SCID)

Border showing unprinted substrate

Images should be printed at approximately the same size

See http://www.color.org/resources/r8-13/CCA_test.xalter
Proposed revision: primary image set

Suggested dimensions
Images scaled so that longest edge is 146 mm including border
Proposed revision: primary image set

Suggested dimensions
Images scaled so that longest edge is 146 mm including border
Proposed revision: secondary set
Proposed revision: secondary set

ISO 12640-3
N2 People
128 x 102.4 mm

ISO 12640-3
N6 Tailor scene
128 x 102.4 mm

ISO 12640-4
N1 Crayons
128 x 96 mm

ISO 12640-4
N3 Yarns
128 x 96 mm

ISO 12640-4
N5 Vases
128 x 96 mm

ISO 12640-4
N2 Flowers
96 x 128 mm

ISO 12640-4
N4 Fishing
96 x 128 mm

ISO 12640-4
N10 Walkathon
85.11 x 128 mm

ISO 12640-4
N11 Spoon
128 x 96 mm

ISO 12640-4
N13 Glass
128 x 96 mm

ISO 12640-4
N14 Beach
128 x 84.8 mm

01_highkey
146 x 105.93 mm

03_lowkey
146 x 105.93 mm

04_cyan
146 x 105.93 mm

05_magenta
146 x 105.93 mm
Candidate print gamuts

**Candidate profiles for Consistent Colour Appearance assessment**

- **CGATS21 CRPC1**: ICC profile registry
- **Uncoated Fogra47L**: ICC profile registry
- **PSR Gravure MF**: ECI web site
- **PSR SC STD V2 PT**: ECI web site
- **SC paper (ECI)**: ICC profile registry
- **Japan Web Coated (Ad)**: Adobe web site
- **Coated FOGRA39**: Adobe web site
- **ColorMaster / Fogra53-5**: Fogra web site

**Note:** It is not intended that these profiles should be used for rendering directly to CMYK. The associated characterisation data may be used directly but with some care the A2B1 tables (Absolute Intent) can be used to determine the colour produced by each CMYK combination.
**Reference printing gamuts**

The set of reference printing gamuts is identified to enable exchange of results when assessing the effectiveness of Consistent Colour Appearance reproduction algorithms.

It is recommended that where possible the characterisation data is used as the primary reference, however, it is recognised that there may be some cases where it is more convenient to use the ICC Profile as a starting point.

In some cases no characterisation data is available. In these cases the A2B1 table data should be used.

### Intended use

- **Reference printing gamuts**
- **Characterisation data**
- **ICC Profile**

<table>
<thead>
<tr>
<th>Reference name</th>
<th>Characterisation data</th>
<th>ICC Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>CGATS21-2-CRPC1</td>
<td>NPES CGATS21-2-CRPC1.txt</td>
<td>ICC profile registry CGATS21-CRPC1.xalter</td>
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<td>FOGRA47I.txt</td>
<td>ICC profile registry Uncoated_Fogra47I_VIGC_300.xalter</td>
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<tr>
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<td>Not available (may be derived from A2B1 and MediaWhitePoint tags)</td>
<td>Adobe detail.jsp?ftpID=4075 (JapanWebCoated.icc)</td>
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<tr>
<td>FOGRA39</td>
<td>FOGRA39I.txt</td>
<td>ICC profile registry Coated_Fogra39I_VIGC_300.xalter</td>
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<tr>
<td>ColorMaster</td>
<td>Not available (may be derived from A2B1 and MediaWhitePoint tags)</td>
<td>Fogra a-large-gamut-exchange-space.html</td>
</tr>
</tbody>
</table>

[http://www.color.org/resources/r8-13/CCA-gamuts.xalter](http://www.color.org/resources/r8-13/CCA-gamuts.xalter)
Reference Display

- **BenQ SW320:**
  - 32” IPS panel
  - UHD 4K Resolution (3840 * 2160) 16:9 ratio
  - 99% Adobe RGB coverage
  - Hardware Calibration capable
  - Special pricing for CIE TC8-16 TC research work.

- **BenQ will work with TC to provide guidance on**
  - calibration procedure
  - viewing environment
Reference proof printer

Would it be useful to have a recommendation for a proof printer, ink set and substrate?

If so, how can we agree this?
Uniform colour space

Demonstration (Image Segmentation)
Segmentation (7 regions) using K-means clustering algorithm

Original
YC_bC_r

CIELAB
IC_TCP

CAM16-UCS
J_2a_2b_2

J_2a_2b_2 and CAM16-UCS papers are available from the CIE COLLTOOL area


Given its ease of use and performance, perhaps J_2a_2b_2 should be recommended
Proposed revision: image preparation

Images should be printed at approximately the same size and original aspect ratio should be retained.

Add a white border to show unprinted substrate if necessary. Note that Roman16 images include a 9 mm border.

Neutral (L* = 50) grey background, ideally ~ Munsell N5.

Background may be on print or display and so may not have a flat spectrum.
Geometry for print or display

Geometry allows viewing of up to 8 reproductions including a reference (bottom right) on a 32 inch display.

Control strips allow checking of display or proof print calibration.
Use of print gamuts

Each set of images is rendered using the same algorithm.

Image colorimetry defined by ISO 12640.
Viewing environment

- ISO 3664:2009 Viewing conditions
- P2 viewing condition
- CIE Illuminant D50
- 500 lx +/- 125 lx (same as ICC PCS)

Hard copy proof

Soft copy proof

- ISO 12646:2008 Display characteristics and viewing conditions
- ISO 14861:2015 Requirements for colour soft proofing systems
- Display colour gamut must be large enough to simulate all reference print gamuts
Psychophysical assessment method

- This assessment method may be used to assess and compare rendering algorithms
  - is there a need for other assessment methods?
- Details of the assessment method need to be provided:
  - instructions for observers
- Can we compare the results of assessment on display with result of assessment of prints?
Measurement assessment

Original image used for psychophysical assessment

kmeans++ clustering

‘Important’ image colours used for measurement assessment

Image reconstruction

Image reconstructed using the important image colours as a confirmation
Algorithm details

The kmeans++ algorithm is described in the following publications:

Measurement assessment

- Would it be useful to recommend an algorithm to extract the set of important colours from an image?
  - This set of colours should be measured as part of any psychophysical assessment in order to provide a basis for subsequent analysis.

- How many colours are necessary to describe an image?
  - I selected 36 as a compromise which produces a reasonable quality reconstruction image and can be measured relatively easily.
  - See result for some of the reference images and the result using 64 colours.

- A set of images that uses these colours could also be provided.

- Would it be useful to have a MATLAB implementation?
Discussion of next steps