ISO/TC 130/WG 3
Process control and related metrology
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Matching Proof & Print under the Influence of OBA

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Introduction

- Print buyers prefer paper with a bluish cast.
- The bluish white of the paper causes two problems:
  - It affects printed colors, including greys and solids
  - There is a mismatch between non-OBA proofs and OBA prints.
ISO 12647-7 (2007) stipulates that the digital proofing substrate be the same as the production substrate and have similar UV responses.

The reality is often the opposite of the above statement.

This case study demonstrates the use of substrate-corrected dataset as a solution to bridge the gap.
Prin7ng Standards

- ISO/DIS 15339-1 (2010) specifies the use of tristimulus linear correction to reconcile the white point difference between the printing paper and the characterization dataset.

- ANSI/CGATS TR 016 specifies tolerances for dataset conformance.

- ISO 13655 (2009) specifies M0 and M1 measurement conditions.

- ISO 3664 specifies M1 viewing (D50).
Pilot Studies at RIT

- Printing to a substrate-corrected dataset (April, 2012)
  - Goss Sunday 2000 web offset press
  - Sappi Opus (OBA) paper
  - Substrate-corrected **SWOP3 (M1)** dataset as the printing aims

- Proofing to substrate-corrected dataset (April, 2012)
  - The psychometric analysis showed that substrate-corrected proof provides better visual match to OBA print than ISO 12647-7 compliant proof where no substrate correction is applied.
Motivation

- To heighten the awareness of the proof-to-print problem and solution, why not conduct a case study involving industry partners?

- RIT invited four proofing vendors (A, B, C, and D) to produce three color-managed proofs.
  - Proof_1 conforms to the SWOP3 dataset as published, i.e., ignoring white point of the printing paper.
  - Proof_2 conforms to the substrate-corrected SWOP3 dataset whereby the white point of Sappi Opus was measured by M0 illuminant.
  - Proof_3 conforms to the substrate-corrected SWOP3 dataset whereby the white point of Sappi Opus was measured by M1 illuminant.
Objectives

- Provide proofing vendors with tools and procedures to produce the three proofs.
- Assess proof conformance according to the CGATS TR016.
- Visually rank the proofs (print as the reference) under the standard viewing conditions.
- Discuss the usefulness of substrate-corrected dataset as the common aims for proofing and printing.
Tools and Procedures

- Digital file of the IT8.7/4 target
- Pictorial reference color images, Bar Set, etc.
- Sample offset print
- SCCA (Substrate corrected Colorimetric Aims) calculator

<table>
<thead>
<tr>
<th>Proof_ID</th>
<th>Source white point</th>
<th>CIELAB</th>
<th>ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof_1</td>
<td>SWOP3</td>
<td>93L*/0a*/0b*</td>
<td>---</td>
</tr>
<tr>
<td>Proof_2</td>
<td>Opus (M0)</td>
<td>93.1L*/1.8a*/-4.8b*</td>
<td>5.1</td>
</tr>
<tr>
<td>Proof_3</td>
<td>Opus (M1)</td>
<td>93.4L*/1.7a*/-6.5b*</td>
<td>6.7</td>
</tr>
</tbody>
</table>
Producing Color Proofs

- Proofing vendors used different equipment, materials, and software to produce these proofs.

- ICC profiles, built from SWOP3 and substrate-corrected SWOP3 datasets, represent the source color space.
  - Proof_1 is generated directly from the SWOP3 dataset.
  - Proof_2 is generated from the substrate-corrected (M0) SWOP3 dataset.
  - Proof_3 is generated from the substrate-corrected (M1) SWOP3 dataset.
Assessing Proof Conformity

- Proof conformity is assessed according to the CGATS TR016 tolerance.
  - IT8.7/4 target of the proof is measured with an i1 iSis (M0) spectrophotometer.
  - An Excel spreadsheet was built to assess proof conformity according to the CGATS TR 016.
  - Deviation and within-sheet variation of each proof was assessed and pass/fail status of the proof determined.

- Proof conformity assessment alone only answers the question if a proof passes or fails.
Printing Standards

- ANSI CGATS TR 016 specifies tolerances for dataset conformance.

<table>
<thead>
<tr>
<th>Conformity Requirement</th>
<th>Target</th>
<th>Sampling</th>
<th>Aim</th>
<th>Tolerance</th>
<th>Decision rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation</td>
<td>ISO 12642-2 (IT8.7/4)</td>
<td>First sheet or OK sheet (n = 1)</td>
<td>Substrate-corrected dataset</td>
<td>Table 1</td>
<td>(1) 95th percentile of ΔE shall not exceed Table 2; (2) Maximum ΔE00 of the 9-patch not exceeds Table 3</td>
</tr>
<tr>
<td>Within-sheet</td>
<td>29 redundant patches in ISO 12642-2</td>
<td>First sheet or OK sheet (n = 1)</td>
<td>---</td>
<td>Table 2</td>
<td>95th percentile of ΔE shall not exceed Table 1</td>
</tr>
<tr>
<td>Production Variation</td>
<td>9-patch, i.e., CMYK solids, CMYK 50% tints, and a near-neutral (50C/40M/40Y)</td>
<td>Multiple sheets from production (n=20)</td>
<td>Substrate-corrected aims</td>
<td>Table 3</td>
<td>For each of the 9 requirements, 95th percentile of ΔE shall not exceed Table 3</td>
</tr>
</tbody>
</table>
Visual & Colorimetric Analyses

- Examine the ISO pictorial color reference image, Bar Set, for colorcast.
- Investigate if non-OBA proof can simulate the white point and grey ramp of OBA print.
- Correlate visual ranking with colorimetric analysis in terms of white point and grey ramp between proof and print.
Results - Conformity of Vendor A

- All three proofs achieved Level A in deviation conformance.
- All three proofs achieved Level A in within-sheet conformance.
- The five largest $\Delta E_{00}$ patches include
  - Outer gamut patches with 100K overprints in Proof_1 and Proof_2
  - Paper (Patch 1367) in Proof_3.
Results - Conformity of Vendor B

- Proof_1 achieved Level B deviation conformance.
  - 100Y was less chromatic.
- Proof_2 achieved Level C deviation conformance.
  - 100Y was less chromatic and 50C was darker and less chromatic.
- Proof_3 failed -- 50C was darker & less chromatic.
- All three proofs achieved Level A within-sheet conformity.
- The five largest $\Delta E_{00}$ patches include
  - Paper (Patch 1367) and highlight cyan patches in Proof_2 and Proof_3
Results - Conformity of Vendor C

- Proof_1 achieved Level B deviation conformance.  
  - Both 100C and 100Y were darker and less chromatic

- Proof_2 and Proof_3 achieved Level C deviation conformance.  
  - 100Y and 50Y were less chromatic  
  - 100C and 50C were less chromatic

- All three proofs achieved Level A in within-sheet conformance.

- The five largest $\Delta E_{00}$ patches include  
  - Paper and cyan highlight patches in Proof_2 and Proof_3.
Results - Conformity of Vendor D

- Proof_1 and Proof_2 achieved Level A in deviation conformance.
- Proof_3 achieved Level B in deviation conformance.
  - 50C is darker
- All three proofs also achieved Level A in within-sheet conformance.
- The five largest $\Delta E_{00}$ patches include lighter patches with two or more overprints.
  - Paper white is not in the five largest $\Delta E$s.
Summary of Proofing Conformity

- Deviation conformance of the three proofs by vendors

<table>
<thead>
<tr>
<th>Proof</th>
<th>Vendor A</th>
<th>Vendor B</th>
<th>Vendor C</th>
<th>Vendor D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof_1</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Proof_2</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Proof_3</td>
<td>A</td>
<td>F</td>
<td>C</td>
<td>B</td>
</tr>
</tbody>
</table>

- All four vendors’ proofs achieve within-sheet Level A conformance.
Visual Ranking of Proofs

- Under the ISO 3664 (2009) compliant viewing booth, observers were asked,
  
  "Which proof is most different in color appearance than the print (reference) ?"
Visual Ranking of Proofs

- Proof_1 was often picked. This was because the yellowness of Proof_1, made from SWOP3 as the source profile, and the blueness of the printing paper are most noticeable.

- To continue the visual ranking experiment, observers placed Proof_2 between Proof_1 and the offset print.
Finally, Proof_3 between Proof_2 and the offset print.
Visual Simulation

- Vendor A’s proofs and the SWOP3 offset print are “soft proofed” with the use of color management.
Visual Ranking & White Point

- The largest color difference (6.2 $\Delta E_{00}$) is between Proof_1 and the offset print.
  - The color difference of the white point reduced to 2.22 $\Delta E_{00}$ for Proof_2, and to 1.63 $\Delta E_{00}$ for Proof_3.

<table>
<thead>
<tr>
<th>Vendor A</th>
<th>Proof White Point (M0)</th>
<th>Printing Paper (M1)</th>
<th>$\Delta E_{00}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L^*$</td>
<td>$a^*$</td>
<td>$b^*$</td>
</tr>
<tr>
<td>Proof1</td>
<td>92.31</td>
<td>-0.25</td>
<td>-0.02</td>
</tr>
<tr>
<td>Proof2</td>
<td>92.83</td>
<td>1.71</td>
<td>-3.87</td>
</tr>
<tr>
<td>Proof3</td>
<td>92.33</td>
<td>1.87</td>
<td>-4.75</td>
</tr>
</tbody>
</table>

- The color difference is visually interpreted as colorcast.
- The colorcast reduction is due to the use of substrate-corrected colorimetric aims in color management.
Visual Ranking & Grey Ramp

- The reference grey ramp is based on SWOP3_SCCA (M1) dataset.
- The print grey ramp is based on the Goss offset (M1).
- The proofing grey ramps are based on Vendor A’s (M0).
- To simulate a grey ramp from a dataset,
  1) Construct an ICC profile from a dataset.
  2) Use the absolute colorimetric rendering of the A-to-B LUT to determine the CIELAB values of the pre-determined CMY triplets.
  3) Plot $a^*$ and $b^*$ of the grey ramp versus the cyan tonal value of the triplets.
Grey Ramp of Offset Print

- Offset print is in solid lines and SWOP3_SCCA(M1) is in dash lines.
  - For grey ramp analysis, SWOP3_SCCA(M1) represents the ideal reference.
Grey Ramp of Vendor A Proof_1

- Proof_1 ignores the printing paper, the starting point of the grey ramps are misaligned.
  - It is perceived as having yellow cast in comparison with the brightened offset print.
Grey Ramp of Vendor A Proof_2

- Proof_2 is aimed at matching the white point of the printing paper, measured by M0.
  - The yellow cast diminishes in comparison with Proof_1.

![Graph showing color differences between A_proof2 and SWOP3_SCCA]
Grey Ramp of Vendor A Proof_3

- Proof_3 is aimed at matching the white point of the printing paper, measured by M1.
  - Despite gamut clipping in the highlight, it matches the brightened offset print the best.
Discussion

- Paper containing OBA affects printing aims (grey and solid) and the appearance of printed color.
- The white point difference between OBA print and no_OBA proof is seen as colorcast.
- When printing and proofing to the same substrate-corrected dataset, visual agreement increases between proof and print in the ISO 3664 compliant viewing condition.
When SCCA is applied to dataset and printing aims, printing conformance is enabled for a wider range of paper.

When SCCA is applied to the source ICC profile in proofing, proof will match print containing OBA.

- The color agreement increases when there is little or no gamut clipping between the proof and the print color spaces.
Conclusion

- This case study explores the ‘M1’ solution, i.e., using M1 measurement conditions, substrate-correction dataset, color management, and ISO 3664 compliant viewing conditions. It shows that
  - Proofing and printing conformity can be assessed per CGATS TR 016.
  - Non-OBA proof can predict the visual appearance of the OBA print when there is no gamut clipping in the highlights, including the substrate color.
Acknowledgments

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  - CGS, Epson America, Global Graphics, GMG Just, GTI
  - Konica-Minolta, X-Rite
- The author also wishes to thank the RIT PSA team for their continuing supports and encouragement.
References

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- ISO/DIS 12647-7 (2007) Graphic technology — Process control for the production of half-tone colour separations, proof and production prints — Part 7: Proofing processes working directly from digital data
- ISO 13655 (2009), Graphic technology — Spectral measurement and colorimetric computation for graphic arts images
Thank you.

Q/A