Gamut index and other metrics for comparing colour gamuts

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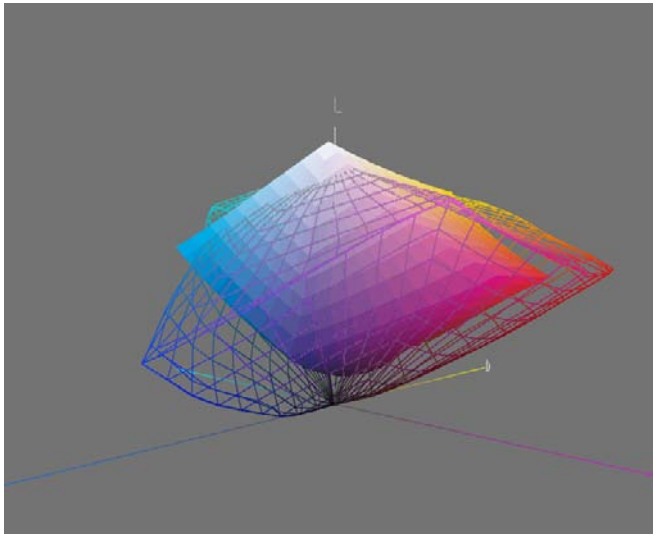
Outline

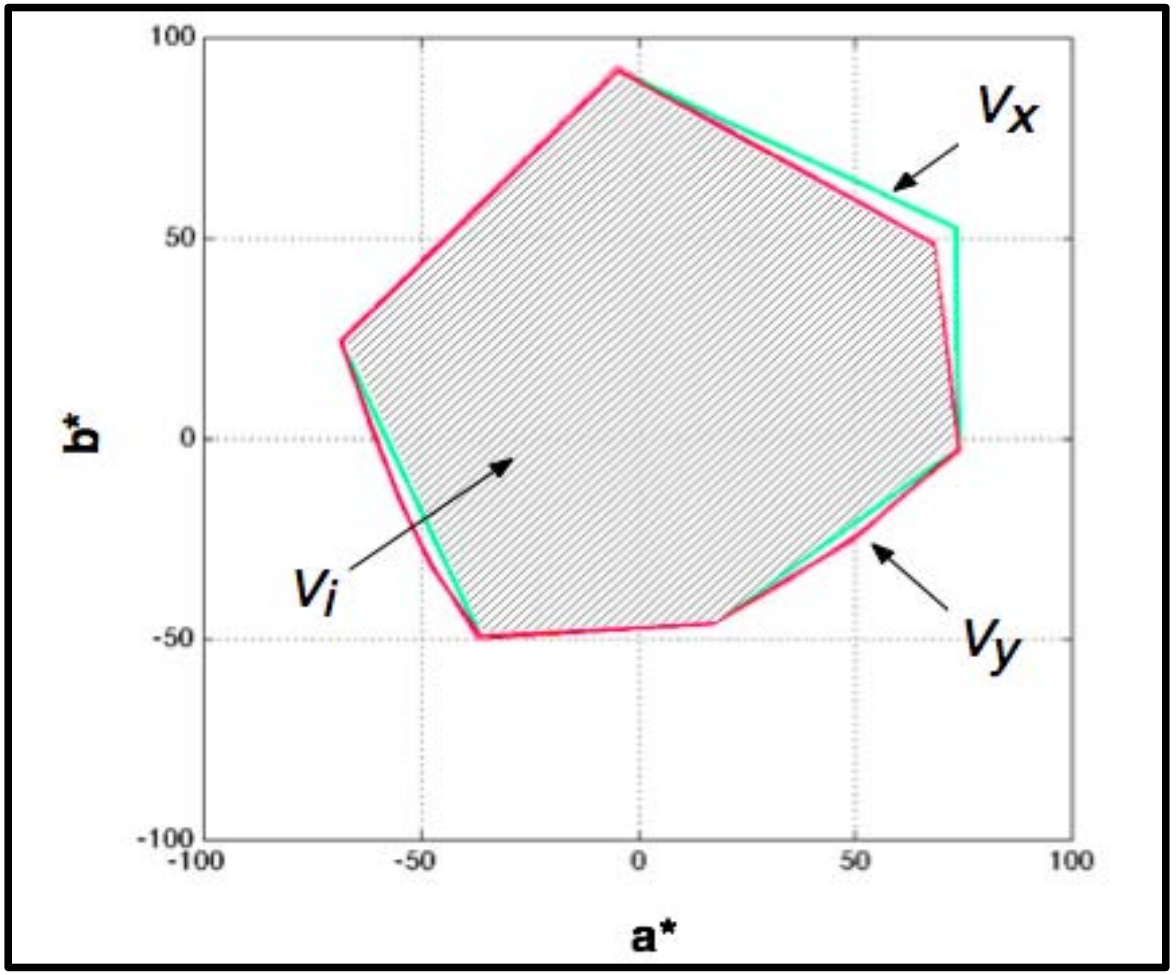
- Background
- Proposed metrics and implementation
- Evaluation of metrics: RPC-8 candidate exchange space
- Applications
- Summary

Background

- We often need to compare two or more colour gamuts
- The difference in gamut volumes alone is a poor indicator
- It can't tell if the gamuts intersect sufficiently to meet the reproduction aims
- Two gamuts having the same volume may not coincide
- Metric needs to include both relative volume and intersection



Gamut comparison index



Gamut comparison index

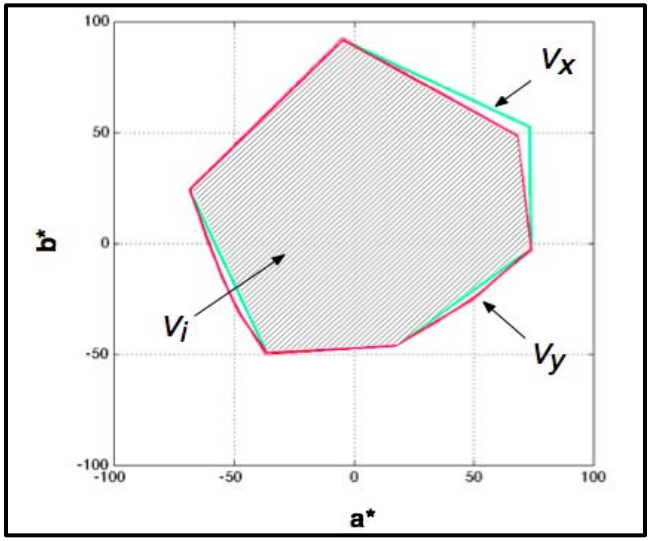
- Gamut comparison index between two gamuts shows how closely they match

$$GCI = \left(\frac{V_i}{V_x}\right)\left(\frac{V_i}{V_y}\right)$$

V_x : gamut volume of the medium x
V_y : gamut volume of the medium y
V_i : volume of intersection of the two gamuts ($V_x \cap V_y$)

New metrics

- $[V_i / V_x]$: how much of gamut x is covered by gamut y
- $[V_i / V_y]$: how much of gamut y is covered by gamut x
- $[(V_x - V_i) / V_x]$: how much of gamut x is outside the gamut y
- $[(V_y - V_i) / V_y]$: how much of gamut y is outside the gamut x
- $[V_x / V_y]$: ratio of gamut x to gamut y
- $[V_y / V_x]$: ratio of gamut y to gamut x



Finding the volume

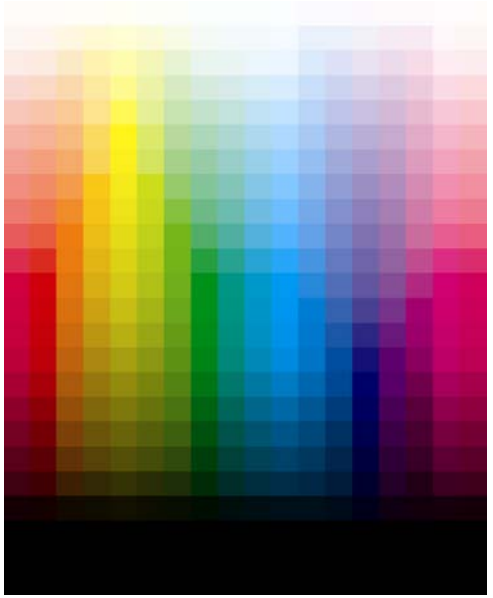
1) Use any method of determining coordinates (vertices) on gamut boundary

2) Determine surface triangles (e.g. by n-dimensional Delaunay algorithm)

3) Generate list of triangle faces

4) Determine set of tetrahedra that fill gamut volume

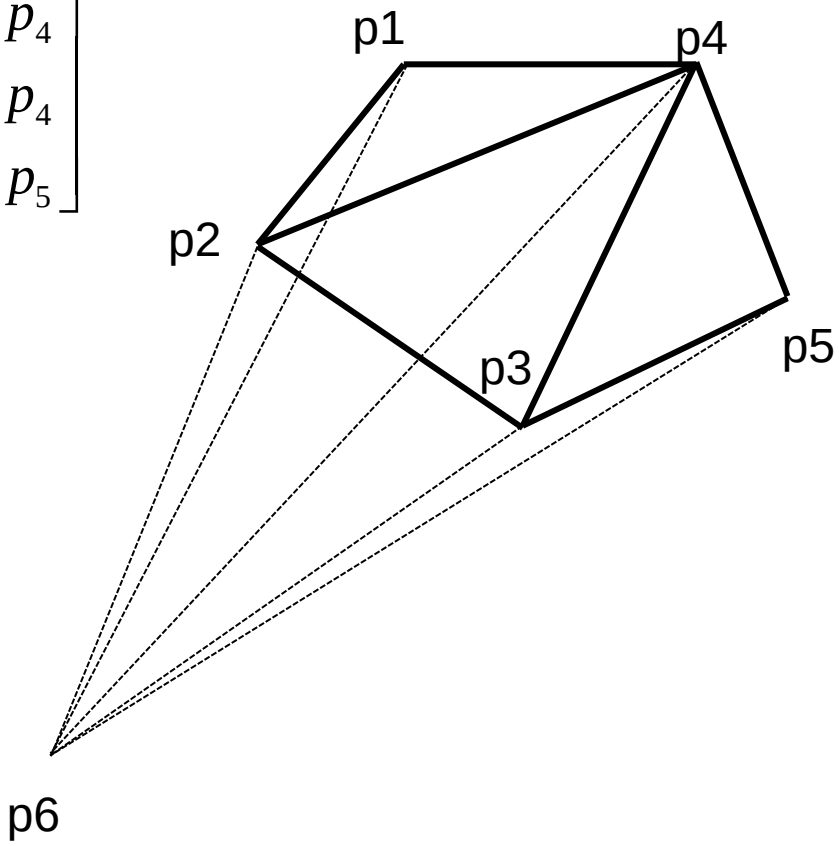
5) Compute volumes of tetrahedra



Finding the volume

For this fragment of gamut surface

Vertices = $\begin{bmatrix} L_1 a_1 b_1 \\ L_2 a_2 b_2 \\ L_3 a_3 b_3 \\ L_3 a_3 b_3 \\ L_5 a_5 b_5 \end{bmatrix}$ Faces = $\begin{bmatrix} p_1 & p_2 & p_4 \\ p_2 & p_3 & p_4 \\ p_3 & p_4 & p_5 \end{bmatrix}$

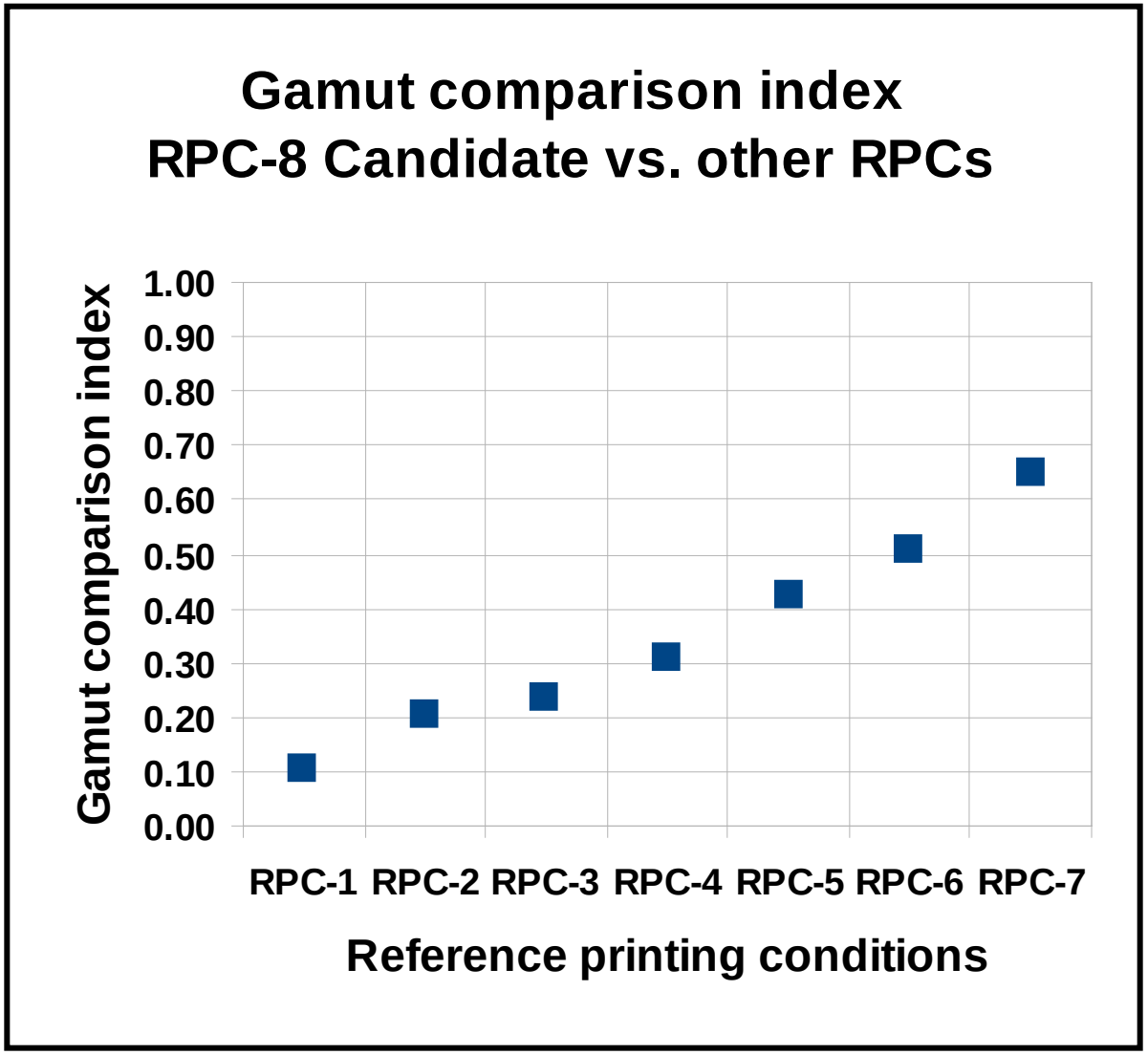


Tetrahedra = $\begin{bmatrix} p_1 & p_2 & p_4 & p_6 \\ p_2 & p_3 & p_4 & p_6 \\ p_3 & p_4 & p_5 & p_6 \end{bmatrix}$

Evaluation

- Selected 7 sample data sets in ISO DIS 15339-1: reference printing conditions (RPCs) which are approximately equal in separation of primaries
  - *RPC-1 Coldset Newspaper*
  - *RPC-2 Heatset Newspaper*
  - *RPC-3 Premier Uncoated Paper*
  - *RPC-4 Super-Calendared Paper*
  - *RPC-5 Publication Coated Paper*
  - *RPC-6 Premium Coated Paper*
  - *RPC-7 Extra Large Gamut*
- Gamut metrics calculated against RPC-8 Candidate (Exchange Space)

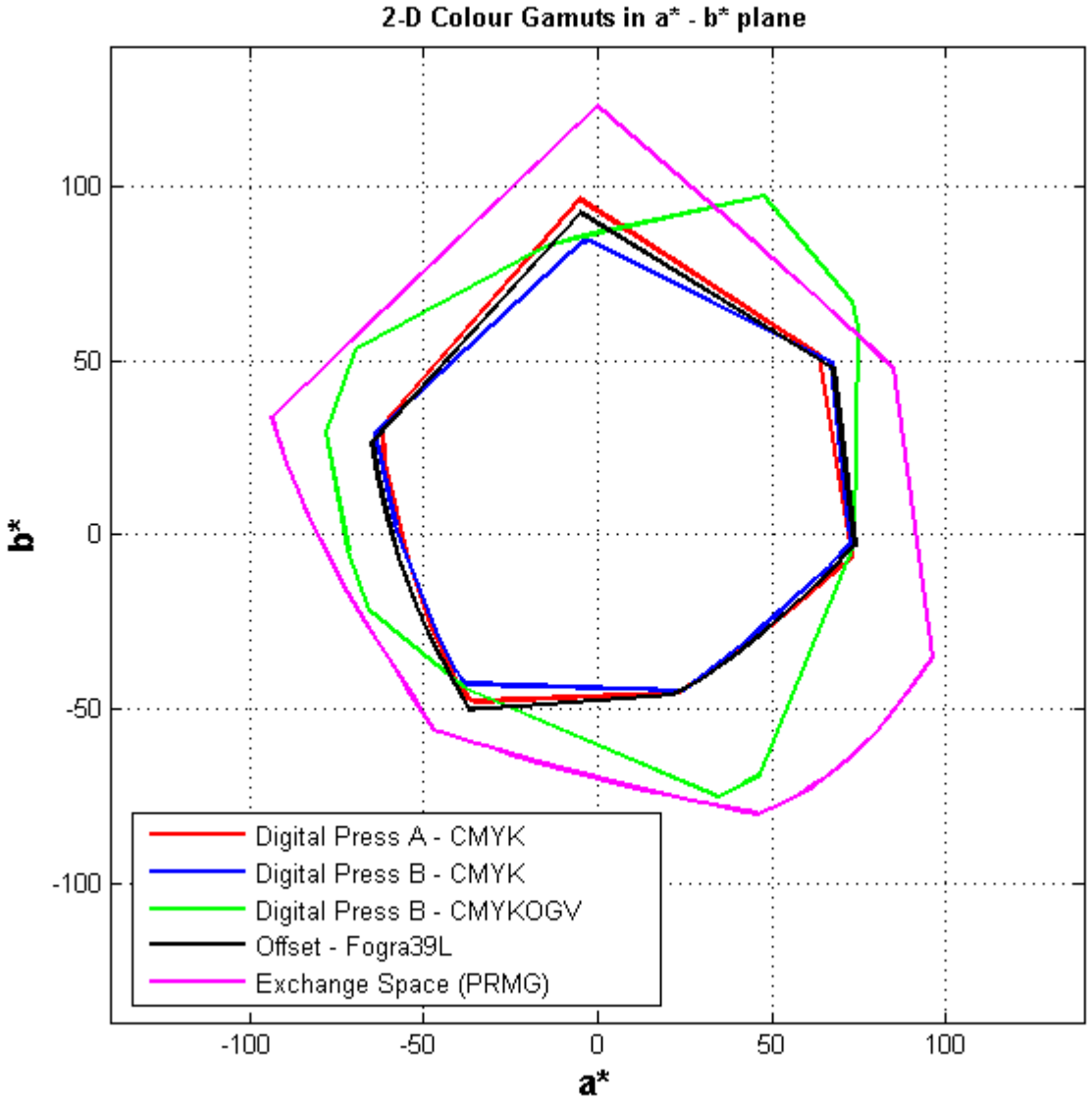
Evaluation


Gamut comparison index
RPC-8 Candidate vs. other RPCs
Gamut comparison index
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
RPC-1
RPC-2
RPC-3
RPC-4
RPC-5
RPC-6
RPC-7
Reference printing conditions

Applications - Digital Printing

- Three digital printing presses compared against the digital printing exchange space profile (RPC-8 Candidate)
  - *Digital Press A: CMYK*
  - *Digital Press B: CMYK*
  - *Digital Press B: CMYKOGV*
- Gamut boundaries derived using convex hull, gamut volume computed in CIELAB space
- Gamut metrics calculated in Matlab

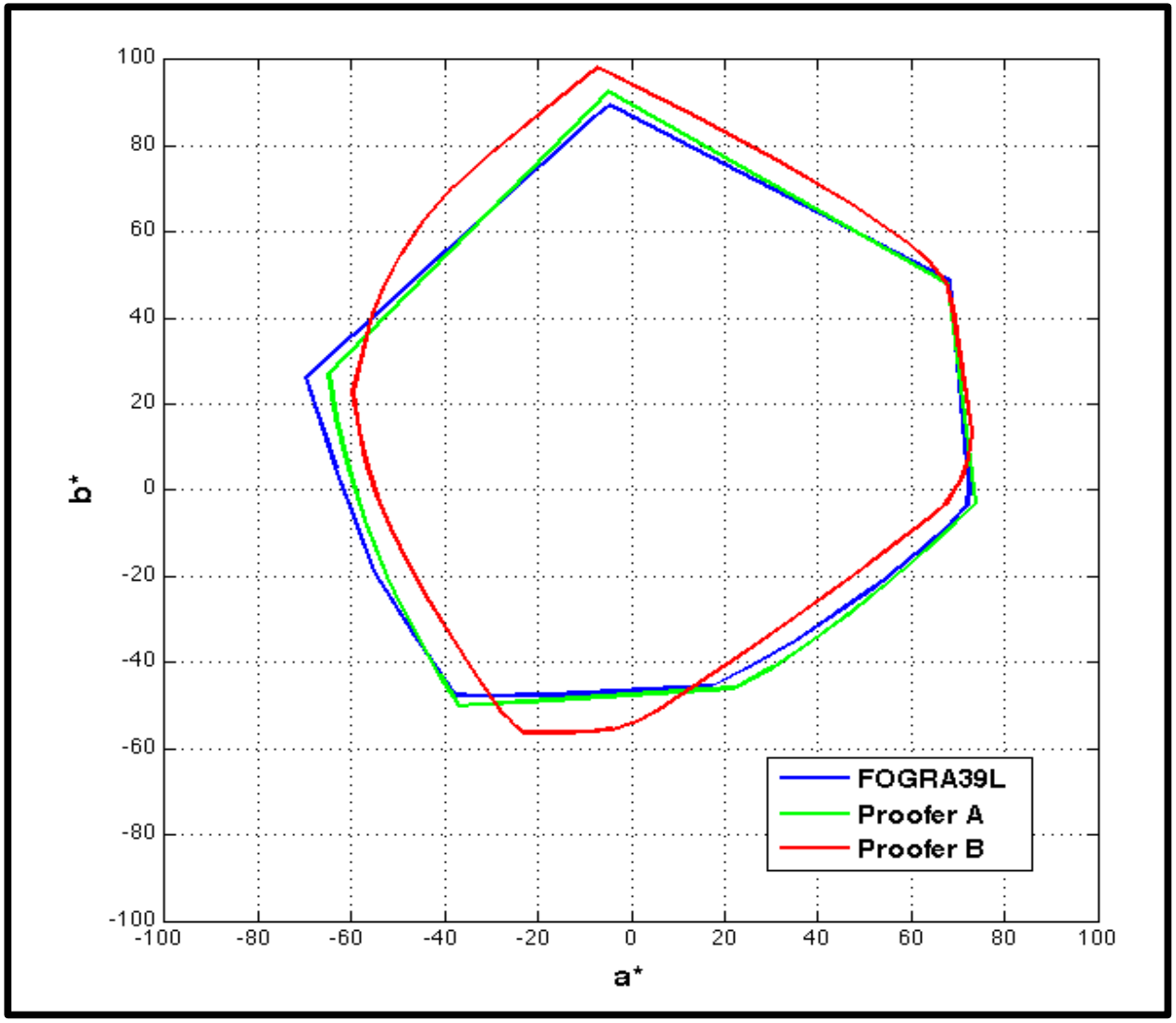
Applications - Digital Printing



Applications - Digital Printing

Gamut x	Gamut y	Gamut x Volume (V_x)	Gamut y Volume (V_y)	Volume of Intersection (V_i)	Gamut Comparison Index $(V_i / V_x)(V_i / V_y)$	Proportion of Gamut x outside the Gamut y $(V_x - V_i)/ V_x$	Proportion of Gamut y outside the Gamut x $(V_y - V_i)/ V_y$
Digital Press A - CMYK	**Exchange Space (PRMG)**	440054	858700	440054	0.51	0%	49%
Digital Press B - CMYK	**Exchange Space (PRMG)**	387813	858700	387813	0.45	0%	55%
Digital Press B - CMYKOGV	**Exchange Space (PRMG)**	709263	858700	676189	0.75	5%	21%

Applications – Proofing



Gamut Volumes

FOGRA39L = 436928

Proofer A = 439187

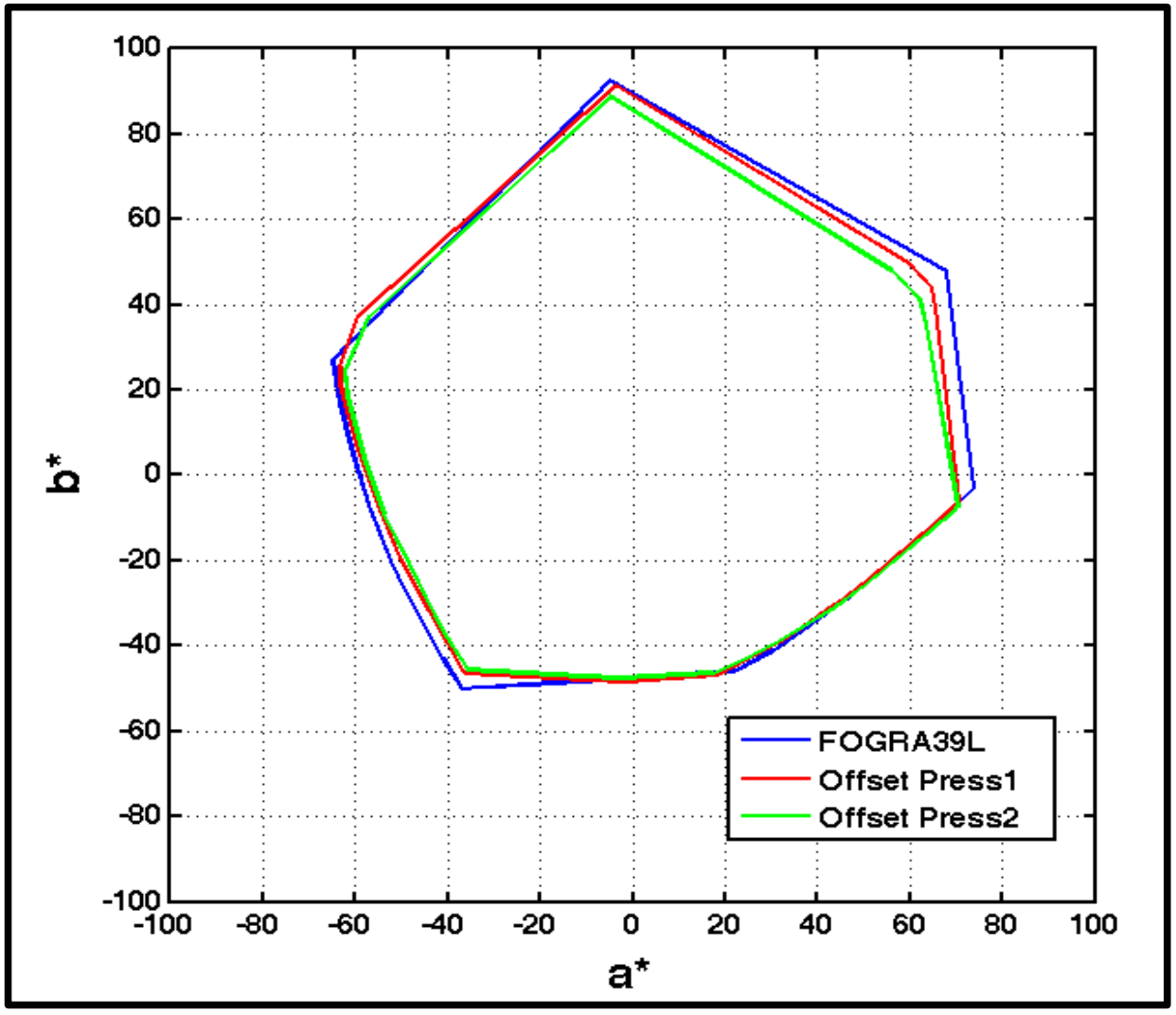
Proofer B = 430872

GCI Values

FOGRA39L & Proofer A = 0.899

FOGRA39L & Proofer B = 0.520

Applications – RPC Validation



Gamut Volumes

FOGRA39L = 436928

Offset Press1 = 418464

Offset Press2 = 388907

GCI Values

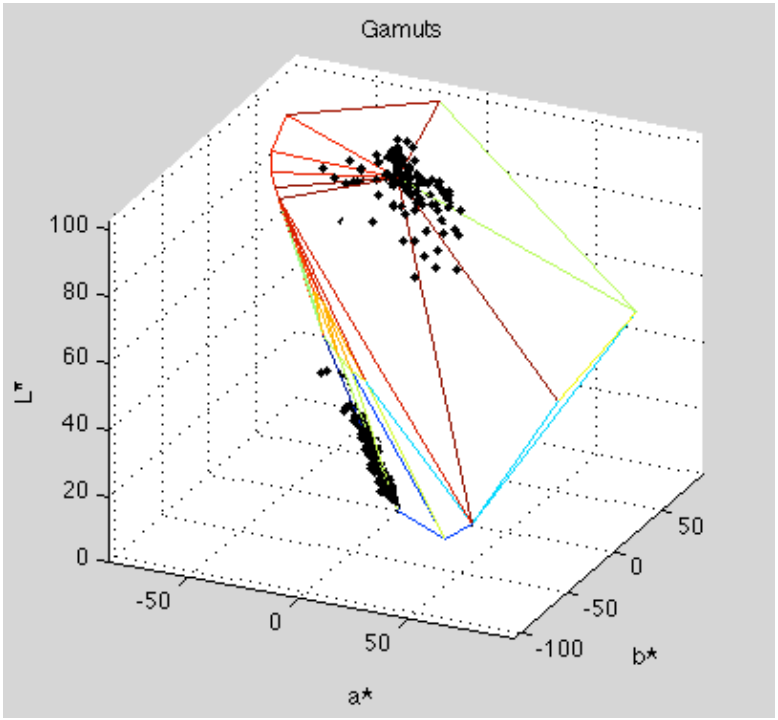
FOGRA39L & Press1 = 0.871

FOGRA39L & Press2 = 0.836

Applications – Photographic Images

- Compare an image gamut to a device gamut – degree of mismatch can guide reproduction process

- e.g. scene-referred colorimetry of image against sRGB gamut



GCI = 0.33

Eric Walowit 31st Jan 2013

Summary

- Gamut comparison index – a single metric for comparing two gamuts predicting the ability of one gamut to match colours in another gamut
- Gamut metrics work well with standard methods of encoding gamut boundaries
- Metrics values can be extracted and computed automatically (e.g. from ICC profile) without requiring visual comparison
- Metrics would be useful to guide the reproduction process: gamut-mapping and re-rendering

Thank You!