Color Gamut Mapping

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Evaluating Gamut Mapping Algorithms

◆ Judgment of performance of the algorithm
  – Color science
    • Color difference equation
    • Measurement of pairs of stimuli

Fig.12.1 Evaluating color difference $\Delta E$ equations
– Evaluation of gamut mapping algorithm
  • Simultaneously compared performed relative to each other
Why is there no reference data set in gamut mapping algorithm evaluation

- Color difference
  - Manageable population of inputs
  - Easily quantifiable input
  - Relatively observer-neutral judgment
  - Relatively few evaluation techniques that can be interrelated
  - Easy evaluation of equation’s predictive powers
– Gamut mapping evaluation
  • Population of inputs is significantly greater and not well characterized
    – Any possible source image
    – Any possible source-destination medium combination
  • Any possible choice of desired reproduction property
  • Quantification of inputs involves more resources
  • Judgment are observer dependent
  • Huge variety in evaluation setups and the use of ratio-scale data
  • Past data cannot be used to evaluate new algorithms
◆ Characteristics of published gamut mapping algorithm evaluation
  – How many GMAs were compared with each other
  – Accuracy vs. preference

![Bar chart](img)

**Fig. 12.3** Number of GMAs evaluated simultaneously in published studies
– Number of observers and test image used to evaluations

Fig. 12.4 Observer and test image numbers in gamut mapping evaluation studies
◆ What can be said on the basis of existing evaluation

– Color-by-color gamut expansion
  • Lightness expansion followed by chroma expansion along the lines of constant hue

– Spectral gamut mapping
  • Use of representing reflectance
  • Retaining metameric black

– Spatial gamut mapping
  • Universally outperform color-by-color
◆ CIE guidelines
  – Recommended a specific way of GMA evaluation
    • Obligatory image: Ski
    • Obligatory pair of GMA: HPMINDE, SGCK

Fig. 12.5 Interrelating experimental evaluation results
Guidelines specify how to report details of the following aspect of GMA evaluation:

- Test image: at least three additional test images
- Media: successfully characterized device is recommended
- Viewing condition
- Measurement: under similar condition
- Gamut boundary: carrying out gamut mapping
- GMAs
- Mapping color space: CIECAM97s recommended
- Experimental method: at least 15 observers and one of the psychovisual test
Studying specific properties of gamut mapping algorithm

- Quantifying either how specific factors affect it or to what extent its output has chosen property
  - Success of GMAs image-dependent
  - Quantified the continuity of GMA transformations
– Image dependence
  • Limitation of current GMA
    – Dependent performance
      » Magnitude and nature of gamut
      » Reproduced images
  • Taking the per-image GMA score
    – Computing coefficients of determination

Table 12.1 Inter-image GMA score correlation in 21 psychovisual experiments.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Data source</th>
<th>Mean ( r^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>MacDonald et al. (1995)</td>
<td>Appendix</td>
<td>0.10</td>
</tr>
<tr>
<td>Wei et al. (1997)</td>
<td>Tables 2 and 5</td>
<td>0.51, 0.33</td>
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<tr>
<td>Morovič (1998)</td>
<td>Appendices D, E, F (glossy &amp; plain paper)</td>
<td>0.47, 0.67, 0.43, 0.16</td>
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<tr>
<td>Braun (1999)</td>
<td>Appendices G (CIELAB/H&amp;B/E&amp;F), P (Xpress/MajestiK), S and W</td>
<td>0.46, 0.41, 0.57, 0.91, 0.61, 0.61, 0.25</td>
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<tr>
<td>Braun et al. (1999b)</td>
<td>Figure 5</td>
<td>0.08</td>
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<td>Katoh and Ito (1999)</td>
<td>Figure 7</td>
<td>0.64</td>
</tr>
<tr>
<td>MacDonald et al. (2001)</td>
<td>Figure 7</td>
<td>0.28</td>
</tr>
<tr>
<td>Motomura (2000)</td>
<td>Figure 7</td>
<td>0.21</td>
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<td>Newman and Pirrotta (2000)</td>
<td>Tables 2–4</td>
<td>0.23</td>
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<td>Chen et al. (2001)</td>
<td>Table 8</td>
<td>0.35</td>
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<tr>
<td>Zeng (2006)</td>
<td>Figure 10</td>
<td>0.16</td>
</tr>
</tbody>
</table>
– Sun’s experiments
  • Weather the difference in a chosen characteristics is removed
    – Artificial test image set

Fig. 12.6 Effect of test image set properties on inter-image GMA performance difference
– Continuity
  • Preserving a source color’s hue predictor
  • Whether small changes in the source also result in small changes in destination
  • Quantifying the continuity (Zolliker and Simon)
    – Randomly pick a color from the source gamut
    – Approximate the unit sphere by a regular polyhedron
    – Map the chosen color and the vertices of its enclosing polyhedron
    – Compute the distances between the mapped chosen color and mapped polyhedron vertices
    – Repeating the computation for a number of samples
      » Yielding frequency histogram for all of the distances
Fig. 12.7 Example of gamut mapping a source color and its unit sphere inscribed polyhedron