Color Gamut Mapping

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- LLIN (linear lightness scaling followed by linear chroma scaling while maintaining hue)
  
  - Mapping lightness
  
  - Chroma compression along lines of constant lightness and hue
    
    - Mapping maximum chroma to maximum chroma

\[
D = G_{D_{\text{min}}} + (S - G_{S_{\text{min}}}) \frac{G_{D_{\text{max}}} - G_{D_{\text{min}}}}{G_{S_{\text{max}}} - G_{S_{\text{min}}}}
\]

Fig. 10.6 The LLIN algorithm: (a) source and destination gamuts; (b) lightness-mapped source gamut; (c) final gamut mapped result. Diamonds represent source and thick line shows destination gamut boundary
Preserving detail than clipping, but some loss of contrast.
• Disadvantage of LLIN
  – Loss of colorfulness and contrast even in this case where source and destination gamuts are of similar shape
  – Large drops in chroma where source and destination gamuts are of different shape

» Display and print

Fig. 10.7 Large chroma drops due to LLIN
• Far more drastic compression than LLIN
  – Preserving the original’s lightness and chroma relationship
    » Small gamut difference
    » Similar gamut shape
  – Low overall chroma and a much more limited lightness range

Fig. 10.8 Uniform global compression
– Initial chroma mapping
  • CLLIN (chroma compression followed by lightness mapping)
    – Finding two cusps in a plane of constant hue
    – Compressing source chroma by the ratio of the destination to source cusp chroma
    – Lightness mapping along the lines of constant chroma and hue
    – Global lightness compression
      \[ D = G_{D_{\text{min}}} + (S - G_{S_{\text{min}}}) \left( \frac{G_{D_{\text{max}}} - G_{D_{\text{min}}}}{G_{S_{\text{max}}} - G_{S_{\text{min}}}} \right) \]

Fig. 10.9  CLLIN – chroma compression followed by lightness mapping
– Hue shift

• Some change to hue can result in great similarity between original and reproduction
  – Better preservation of source lightness and/or chroma by hue shift

\[
D = S_h + \frac{\text{huedif}(S_h, S_{hpc}) \times \text{huedif}(D_{hpc}, S_h) \times \text{huedif}(S_{hpc}, S_h) \times \text{huedif}(S_h, D_{hpc})}{\text{huedif}(S_{hpc}, S_{hpc})} p
\]

where \( P_c \) is the primary or secondary that has a source hue closest to the source color’s hue in the clockwise direction, \( P_{cc} \) is closest in the counterclockwise direction, the \text{huedif}(a,b) function gives the counterclockwise distance from hue angle \( b \) to hue angle \( a \), \( P = [0,1] \) is the percentage of hue shift.

Fig. 10.10 Hue shift determined by source and destination primaries and secondaries
Simultaneous mapping in constant hue plane

- What gamuts to map between
  - Original and reproduction medium’s gamut
  - Source image gamut
    - Multiple gamut according to image
  - Designing region of the destination gamut
    - Combination of clipping and compression
– Mapping toward a single point (focal point) in a constant hue angle plane
  • Most basic simultaneous mapping approach
    – Compressing along lines towards a single point
  • SLIN
    – Not having an initial lightness compression
    – Providing result that is somewhere between LLIN and clipping
    – Poor result in large gamut difference
      » Printer and display
  • Modified SLIN
    – Varying a focal points according to hue or cusp
Plate 11: Reproduction obtained using LLIN in CIECAM02

Plate 13: Reproduction obtained using SLIN in CIECAM02
• CARISMA algorithm
  – Single focal points in planes of constant hue angle after an initial lightness mapping
    » Focal point on the lightness axis where the line connecting the source and destination cusp
    » Focal point on the chroma axis that has half the chroma of the destination cusp at that hue

Fig. 10.12 Two of the three component algorithms of Johnson’s CARISMA
Plate 3: Source image printed on coated (glossy) paper

Plate 14: Reproduction obtained using CARISMA in CIECAM02 (using only mapping to intersection between lightness axis and line connecting cusps)
• Buring and Herzog method
  - Focal point in the hue plane that is 180’ to the current one
    » Less lightness reduction
    » Resulting in negative chroma

Fig. 10.13  Mapping towards a point with negative chroma
- Mapping towards multiple focal points in constant hue angle planes
  - Dividing source color into regions and applying different mappings to each
  - K is a point along the line between the lightness axis and the destination cusp
    - Ito and Katoh’s four region compression
      » A: core region, where source colors are kept unchanged
      » B: region, where source colors are compressed towards K
      » C: shadow region, where source colors are compressed toward the destination white point on the lightness axis; and
      » D: highlight region, where colors are compressed towards the destination black point again on the lightness axis
- Neumann and Neumann
  - Making the core region a scaled version of the destination gamut
– Lee et al’s algorithm

• Dividing the source gamut into three lightness range
  – Parameterization of gamut mapping depending on relationship between two gamuts
    » Basis of the mean of the source and destination lightness

Fig. 10.15 Lee et al’s subdivision of the source gamut dependent on both source and destination cusp lightness
- **Kang et al.’s GCA algorithm**
  - Dividing the source gamut into three lightness range
    - Mapping the chroma along lines of a constant lightness in the middle range
    - Mapping the top and bottom range towards the top and bottom boundary of lightness
      » Boundary is determined by psychovisual experiment

![Diagram showing the three mapping regions of Kang et al.’s GCA algorithm](image_url)