The Norwegian
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Consistent Colour Appearance: proposed work at the NTNU ColourLab, Gjøvik, Norway

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Gregory High – Personal Background

- Background in graphic design and print production
- Responsibility for colour management, proofing and pre-media in Design Studios and Advertising Agencies
- Member of UK TC-130 technical advisory group
- MSc Digital Colour Imaging in 2008
  at London College of Communication
- Joined the PhD programme at NTNU ColourLab,
  Gjøvik in November 2015

NTNU Colourlab in Gjøvik, Norway

- Norwegian Colour and Visual Computing Laboratory
- Founded in 2001
- www.colourlab.no

A model of consistent colour appearance

The PhD project's objective is to build a ***model of consistent colour appearance*** for graphic arts and colour display applications.

The aim is to facilitate colour reproductions across different output media (e.g. retargeting) that create, as closely as possible, an appearance match relative to the context and viewing conditions of each medium.

The scope of the project is limited to colour appearance;
other appearance attributes are excluded*.

* Material appearance is addressed within the MUVApp project at NTNU Colourlab

Recent work at Gjøvik – paper at Electronic Imaging 2017

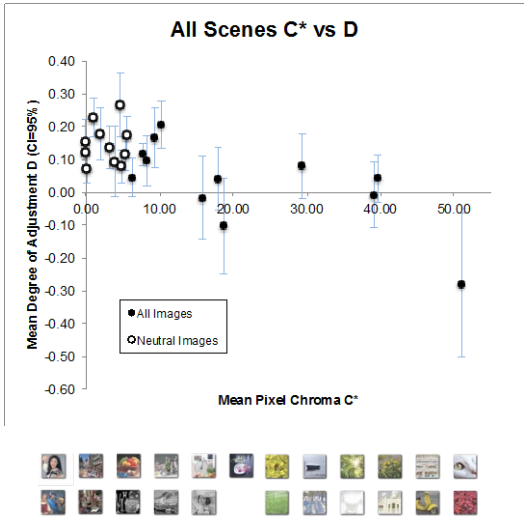
Content-dependent adaptation in a soft proof matching experiment*

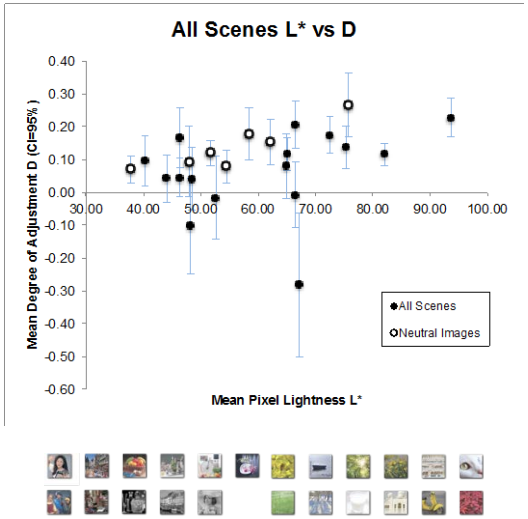
- High, G., Green, P. & Nussbaum, P., 2017. Content-dependent adaptation in a soft proof matching experiment. *Electronic Imaging*, 2017(18), pp.67–75.

- This experiment looked at the **media relative transform only** (lightness scaling, BPC and gamut mapping were excluded)
- **Method of adjustment**: the degree of adaptation applied to the reproduction was adjusted to make an appearance match
- The match was found to be partly **image content dependent**

Recent work at Gjøvik – Results & Conclusions

- Some correlation between image content and degree of adaptation
- To make an appearance match, observers applied an adjustment that was closer to a media-relative transform for lighter, more neutral images
- A far stronger effect was seen for colour patches





Reference: works on colour & image difference metrics

- TC 8-02 "Colour Difference Evaluation in Images" (see CIE 199:2011)
- Recommends ***parametric factors*** to get an average image pixel ΔE to agree more closely with reported visual difference (e.g. k_L*=2)
- Previous work shows good results when parametric factor is optimized for the colour difference ***formula*** used[1]
- Also, colour difference formulae may be optimized for the expected ***size*** of the difference[2] (CAM02-LCD, CAM02-SCD, etc.)

1. Liu, H. et al., 2013. Color-difference evaluation for digital images using a categorical judgment method. *JOSA A*, 30(4), pp.616–626.

2. Luo, M.R., Cui, G. & Li, C., 2006. Uniform colour spaces based on CIECAM02 colour appearance model. Color Research & Application, 31(4), pp.320–330.

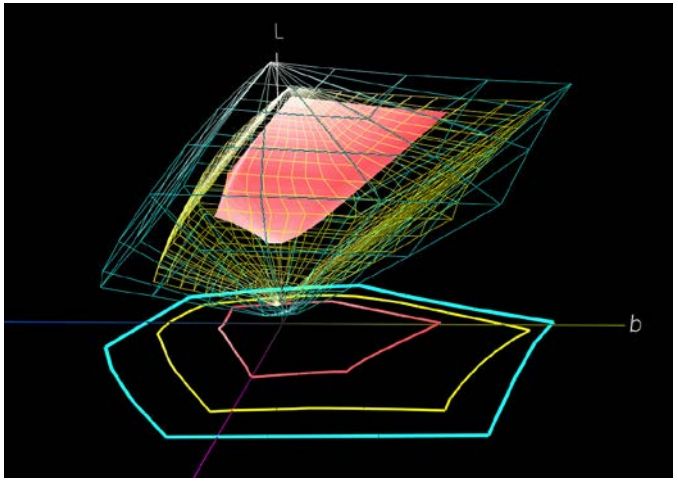
Towards a metric of dissimilarity?

- A metric of '***consistent colour appearance***' is a desirable outcome of the project
- This points to an appearance difference approach (rather than a colorimetric difference approach)

- '***Dissimilarity***' describes a subjective, observer-orientated appearance difference that is relative to the reproduction media and viewing conditions

Visual dissimilarity vs Image Colour Difference

- Simultaneous viewing of:
  - 3 or more images
  - Both large and small colour differences
  - Different substrate whitepoints
- Range of differences:
  - GMG color (largest gamut) vs Newsprint (smallest gamut)
    Colorimetric difference between whitepoints is approx. 12 ΔL*, approx. 7ΔC^*_{ab})
  - Even greater differences related to tonal compression and chroma compression (i.e. differences in gamut volume and shape)



Visual dissimilarity: the visual differences constrained by CIE TC 8-16's proposed setup

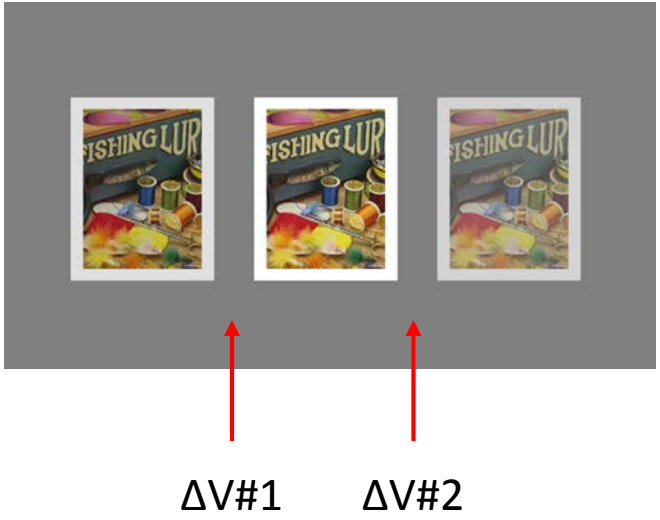
- Standardized viewing conditions (P2)
- Consistent image size with unprinted border
- The differences are media-specific (gamut mapping-type transforms and constraints)
  - Lightness scaling (inc. blackpoint compensation and tonal compression)
  - Chroma scaling
  - Media-relative hue shift

Aims of proposed experiment

- Build a scale of visual difference (ΔV) based on the TC 8-16 experimental constraints
- Quantify the effects on simultaneous comparison from:
  - the computed difference-interval between pairs
  - perceived comparative differences
- Identify image-dependent aspects of simultaneous comparison
- Identify any practical problems in the TC 8-16 setup

Proposed experiment: building a ΔV scale from simultaneous comparisons

- Preferred method: magnitude estimation of visual difference
- Randomized presentation of three constrained renderings* (not two images compared to a reference)
- Observers make two estimations of visual difference (ΔV#1 and ΔV#2)



* May be considered a subset of the TC 8-16 proposed experiment

Experimental setup – based on TC 8-16 proposal[3]

- Standard viewing conditions: ISO 3664, ISO 12646, ISO 14861

  Print orientated, P2 viewing conditions, dim surround, neutral grey background, display conformance, etc. are all well defined

- Issues of concern relating to large format, wide gamut displays

  Some potential sources of disagreement between shared results are:

  – viewing geometry and uniformity (esp. maximum angle of subtense and fall-off)
  – blackpoint clipping/crushing due to flare light,
  and method of encoding and retrieving this from the display profile
  – backlight spectral power distribution
  (esp. differing narrowband primaries associated with wide colour gamut)

3. http://color.org/resources/consistentappearance.xalter

Recording observer behaviour

- Understanding ***how*** our observers use the images provides good insight into the ***process*** of image comparison, but this is difficult to record
- Eye-tracking will determine observer reference points across a set of image (in addition to metrics-based image analysis)
  - We propose to test a “bolted-on” eye-tracking solution (operated separately from the colour managed display)

Open questions… help please!

- What are the expected complications of simultaneous comparisons and magnitude estimations?
- Given the mix of large and small colour differences and visual differences, what scale would be appropriate to use for the magnitude estimation?
- How best to deploy ‘anchor pairs’ in observer training and throughout the experiment?

Thank you for your attention

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