Measuring Images: Differences, Quality and Appearance

Garrett M. Johnson
Mark D. Fairchild
Munsell Color Science Laboratory
Rochester Institute of Technology
The Evolution

- Image Difference Metrics
- Image Appearance Modeling
- Image Quality Modeling
Image Difference Metrics
Image Difference Metrics
Image Appearance Modeling
Image Quality Modeling
Modular Image Difference Framework

- Input is 2 colorimetrically characterized images
- Spatial Filtering
  - Inspired by S-CIELAB
  - Spatial Modulation and Enhancement: Get rid of information we cannot see, enhance information where we see best
- Built upon CIE Color Difference Formulae
Modular Image Difference Framework

- Independent Modules, or building blocks
- Spatial Filtering & Spatial Frequency Adaptation - adjust CSF for complex stimuli
- Spatial Localization - detect differences between edges
- Local & Global contrast detection
- Color space and color difference equations - CIELAB, CIE E94, Insipid CIEDE2K
Experimental Prediction

- Use psychophysical experiments to evaluate and develop image difference framework
- Image Sharpness
  - Johnson & Fairchild - CIC8
  - Resolution, Contrast, Noise, Filtering
- Image Contrast
  - Calabria & Fairchild - CIC10
  - Lightness, Chroma, Sharpness
Typical Image Difference Predictions

Graph showing a scatter plot with labels on the axes:
- Model Prediction
- Experimental Scale

The graph displays data points and a trend line, indicating a correlation between the model predictions and the experimental scale.
Typical Image Difference Predictions

- Typically “V” shaped
- Image difference metric cannot determine direction, only magnitude
- Some images are more sharp than original, some less: Model cannot differentiate
Image Difference Predictions

- Contrast Experiment
- Single dimension of variation
Appearance Attributes

• We are capable of predicting overall differences rather well
  • Especially single variable differences
• Cannot determine the cause of the differences
  • Magnitude but not direction
• To determine the cause of the differences we need more information about the image appearance
• Color difference equations, such as CIEDE2000 only reveal overall magnitude of perceived differences

• To understand the root cause of color differences we can examine individual color changes: DL*, DC*, DH*

• A similar approach can be taken with spatially complex image differences
Resolution Detection

- Standard Deviation of CIELAB L* Error After Spatial Frequency Adaptation
  - Most Sensitive to high frequencies
  - Error is large for high frequencies, small for lower frequencies
- Spatial localization module is designed to detect changes in edge information
- Output from spatial localization module can be used to detect changes in “Sharpness”
Contrast Detection

- Contrast module designed to detect both global and local changes in image contrast
- Examining the output from this module can determine if overall image differences are a result of changes in contrast
• Ideally the output from each of the image difference modules would have some psychological meaning.

• Image appearance correlates are desired in a meaningful color space: sharpness, contrast, graininess, lightness, chroma, hue.

Colorspace does not have to be CIELAB. It is just another module in the framework. It can be easily replaced with a color appearance model.
iCAM: An Image Appearance Model

- Introduced a framework for an image appearance model at CIC10
- It is based upon the modular image difference framework, and the IPT appearance space.
- Designed to predict appearance correlates of complex stimuli
Towards Image Quality Modeling

- Use what we’ve learned to get independent appearance variables
- Build those together to get quality metrics as functions of appearance
  - Minkowski Metrics: Weighted sum of color, sharpness, contrast, etc.
Conclusions

• Image Difference Metrics
  • Modular framework is capable of predicting general magnitude of perceived image differences
  • Like traditional color difference equations, it is incapable of predicting direction or cause of differences

• Image Appearance Models
  • Extend framework using color appearance spaces
  • predict image appearance correlates such as sharpness and contrast
  • iCAM: First attempt at such a model

• Image Quality Models: Built upon image appearance correlates
Acknowledgements

Image courtesy of www.fujifilm.co.jp/sapporo/tokusyu/index.html