

Meet iCAM: A Next-Generation Color Appearance Model

CIC X, 2002

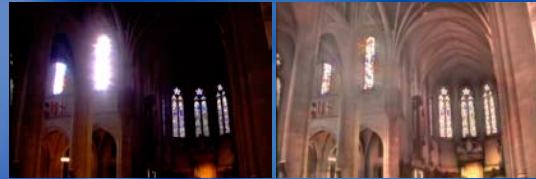


Say hello to
iCAM



Mark D. Fairchild & Garrett M. Johnson
RIT Munsell Color Science Laboratory
www.cis.rit.edu/mcsl

Why Are We Here?



- Spatial, Temporal, & Image Quality Questions Remain
 - *E.g. Pattanaik et al. 1998*

Outline

- Very Brief History of Color Appearance Models
- Image Appearance Modeling
- iCAM: An Image Appearance Model
- Future Directions

Very Brief History of Color Appearance Models

- You've just heard two talks on CIECAM02
- Enough said...

What Does a Color Appearance Model Enable?

- Mapping from Measurements to Words (Physics to Perception)
- Prediction of Color Matches (or Changes) across Changes in Viewing Conditions

Appearance Correlates

- Brightness, Lightness
- Colorfulness, Chroma, Saturation
- Hue



History of Color Appearance Models

- 1970's: CIELAB and CIELUV
- Early 1980's: Initial Hunt and Nayatani Color Appearance Models
- Late 1980's: Revisions of Hunt and Nayatani Models
- Early 1990's: Model Testing, Further Revisions, New Models (e.g., RLAB, LLAB)
- Late 1990's: Convergence ... CIECAM97s
- Early 2000's: Widespread focused testing and refinement, CIECAM02, Practical Image Appearance Models

A Next Generation CAM



CIECAM02 is an Evolution of CIECAM97s
New Capabilities Require a New Approach ...

What is an Image Appearance Model?

- Image appearance models extend color appearance models to include spatial vision, temporal vision, and image difference/quality properties.
- They account for more complex changes in visual response in a more automated manner



What are Some of the Missing Links?

- Spatial Vision (Filtering & Adaptation)
- Scene Interpretation
- Computational Surround Effects
- Color/Image Difference Metrics
- Image Processing Efficiencies



MOM

Pattanaik, Ferwerda, Fairchild, & Greenberg, SIGGRAPH and CIC (1998)

Multi-Scale Observer Model

- Comprehensive
- Extremely Complex
- Successfully Implemented 2-3 Times!!



Image Quality Measurement

Johnson & Fairchild, CIC (2001)

Modular Framework for IQ Scales

- Promising Framework for Image Differences
- Flexible Implementation

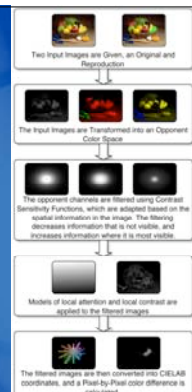


Image Difference Process

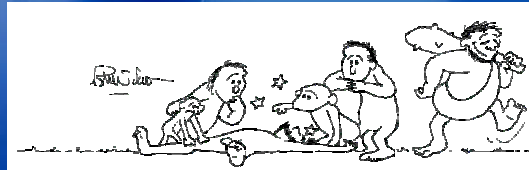


Spatial Filtering, Local Attention, Local & Global Contrast, CIE Color Difference

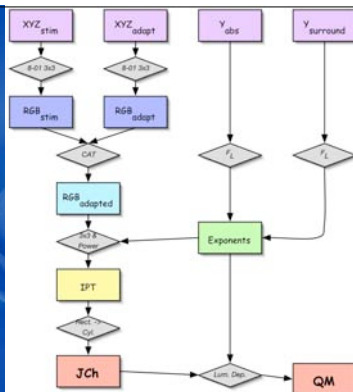
Meet iCAM

iCAM — *image Color Appearance Model*

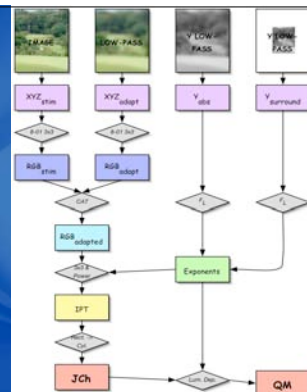
A simple framework for color appearance, spatial vision effects, image difference (quality), image processing, and temporal effects (eventually).



Pointwise iCAM



Spatial iCAM



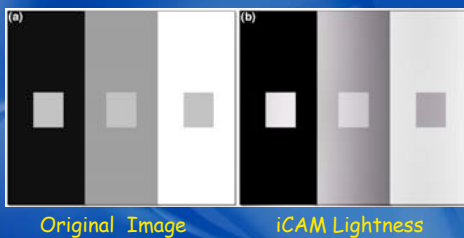
iCAM Performance Examples

- Chromatic Adaptation Transform (CAT)
 - Color Appearance Scales
 - Constant Hue Lines
 - Simultaneous Contrast
 - Chroma Crispening
 - Hue Spreading
 - HDR Tone Mapping
- Image Difference (Quality)

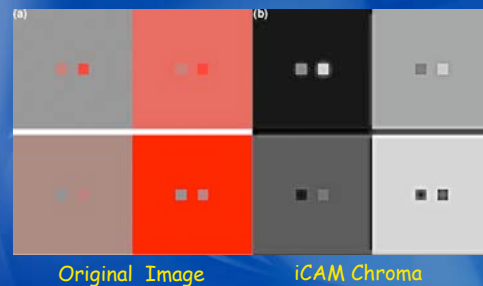
Basic Appearance Attributes

- Chromatic Adaptation Transform (CAT)
 - Identical to CIECAM02
- Color Appearance Scales
 - Similar to Munsell / CIECAM02 (limited)
- Constant Hue Lines
 - Best Available (IPT)
 - Facilitates Gamut Mapping

iCAM Simultaneous Contrast

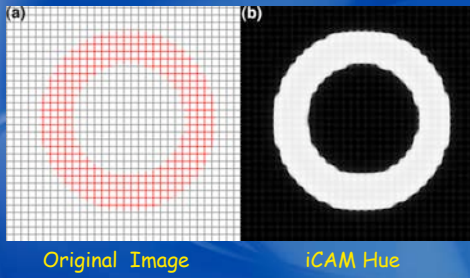


iCAM Chroma Crispening

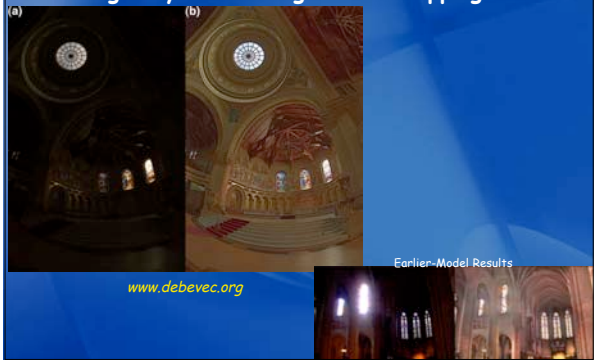


http://www.hpl.hp.com/personal/Nathan_Moroney/

iCAM Spreading



iCAM High-Dynamic-Range Tone Mapping



iCAM Image Difference (Image Quality)

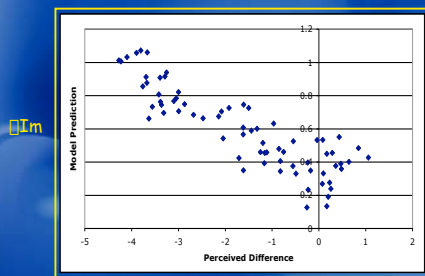


Image Difference Prediction (Sharpness Data)

iCAM Image Difference (Image Quality)

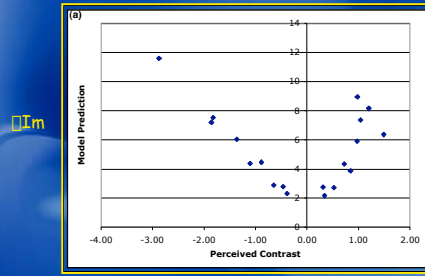
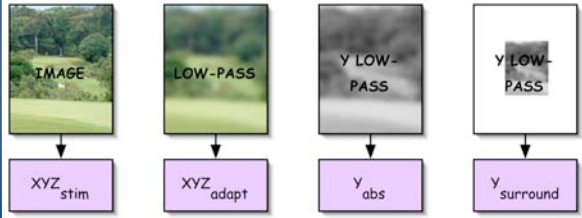


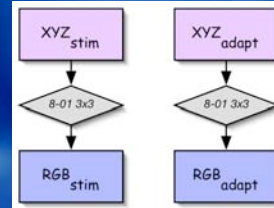
Image Difference Prediction (Contrast Data)

Image Input Data



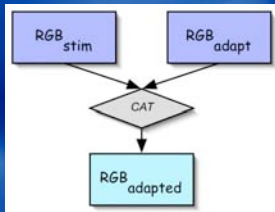
*XYZ_{adapt}: Different Filters for luminance & chromaticity TBD
All Filters: Viewing-Distance Dependent*

Transform to "Sharpened Cone Responses"



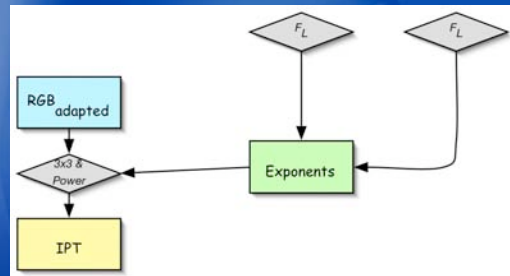
The same 3x3 as adopted for CIECAM02.

TC8-01 (CIECAM02) Linear CAT



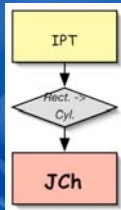
The same CAT as CIECAM02 for simple conditions.

Surround & Luminance Dependent Transform to IPT Color Space



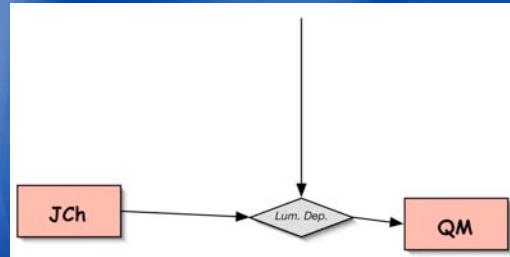
"Contrast" depends on luminance and surround.

Rectangular-to-Cylindrical Lightness, Chroma, Hue



Just plain geometry.

Conversion to Brightness, Colorfulness



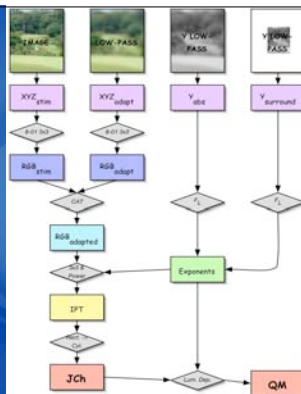
Dependency on absolute luminance.

Spatial iCAM

Detailed references to each step in proceedings.

Coded examples on the internet.

Open-Source Science



Mathematica Notebooks



- Can be read and executed with free "MathReader".
- Other code (Matlab, IDL) forthcoming.
- Updates

Conclusions

- iCAM Represents an Example of a New Generation of Color Appearance Model
- Image Appearance Model
- Incorporates Spatial Vision
- Can Be Extended for Temporal Vision (EI 2003)
- Image Difference Metric, ΔIm (EI 2003)
- Basis for a Fundamental Image Quality Metric

Future Directions

- HDR Digital Photography (Capture & Processing)
- Video iCAM (Temporal Adaptation & Filtering)
 - HDR Digital Video (Processing)
 - Better Understanding of Surround Effects
 - Image-Content Dependent Reproduction
- Refined Image Difference & Image Quality Metrics
 - Extension to Preferred Image Reproduction
 - Psychophysics, Psychophysics, Psychophysics

Suggestions and Help Welcome and Encouraged