iccMAX for the Real World

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NPES International Color Consortium IPAMA

Agenda

- Mission of ICC
- Basics of Color
- Introducing iccMAX
- iccMAX Color Communication Scenarios
- What lies Ahead

ICC Mission Statement

- The purpose of the ICC is to promote the use and adoption of open, vendor-neutral, cross-platform **color management** systems.

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- The ICC enables the “Communication of Color”

What is Color?
How do you communicate about it?

Basics of Color

Light Source

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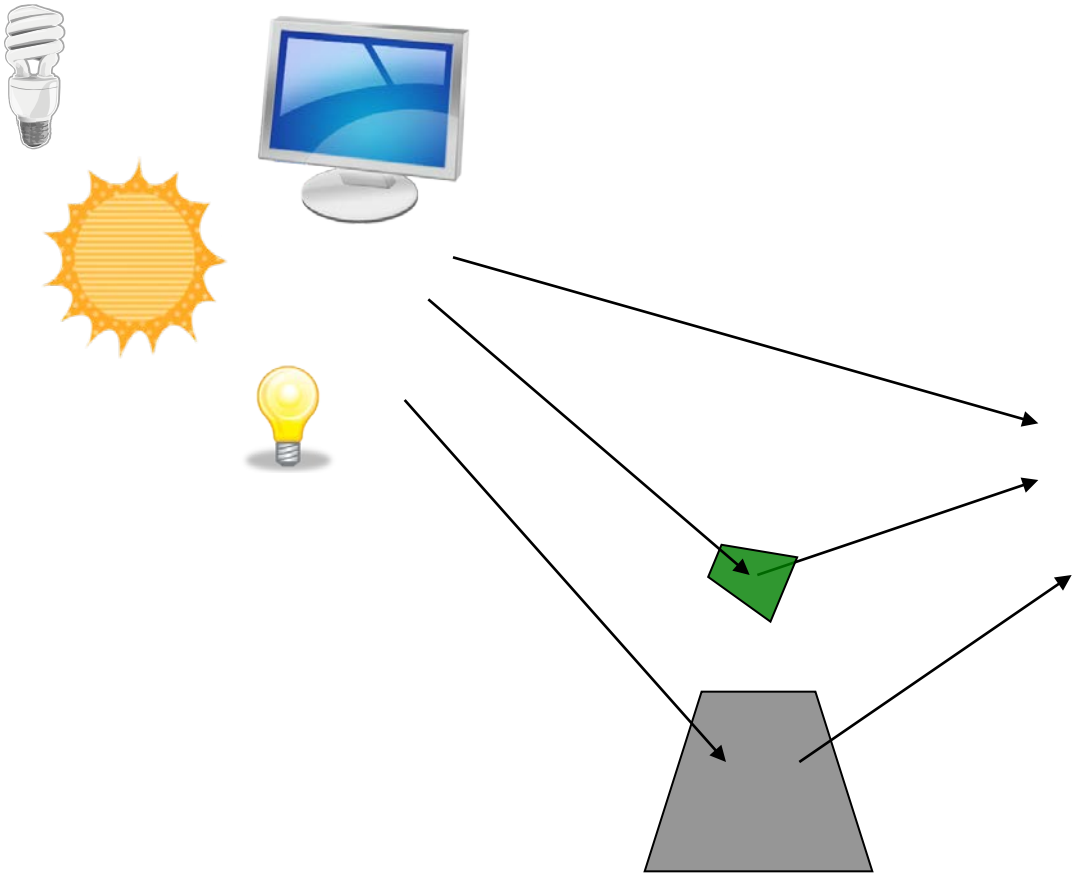
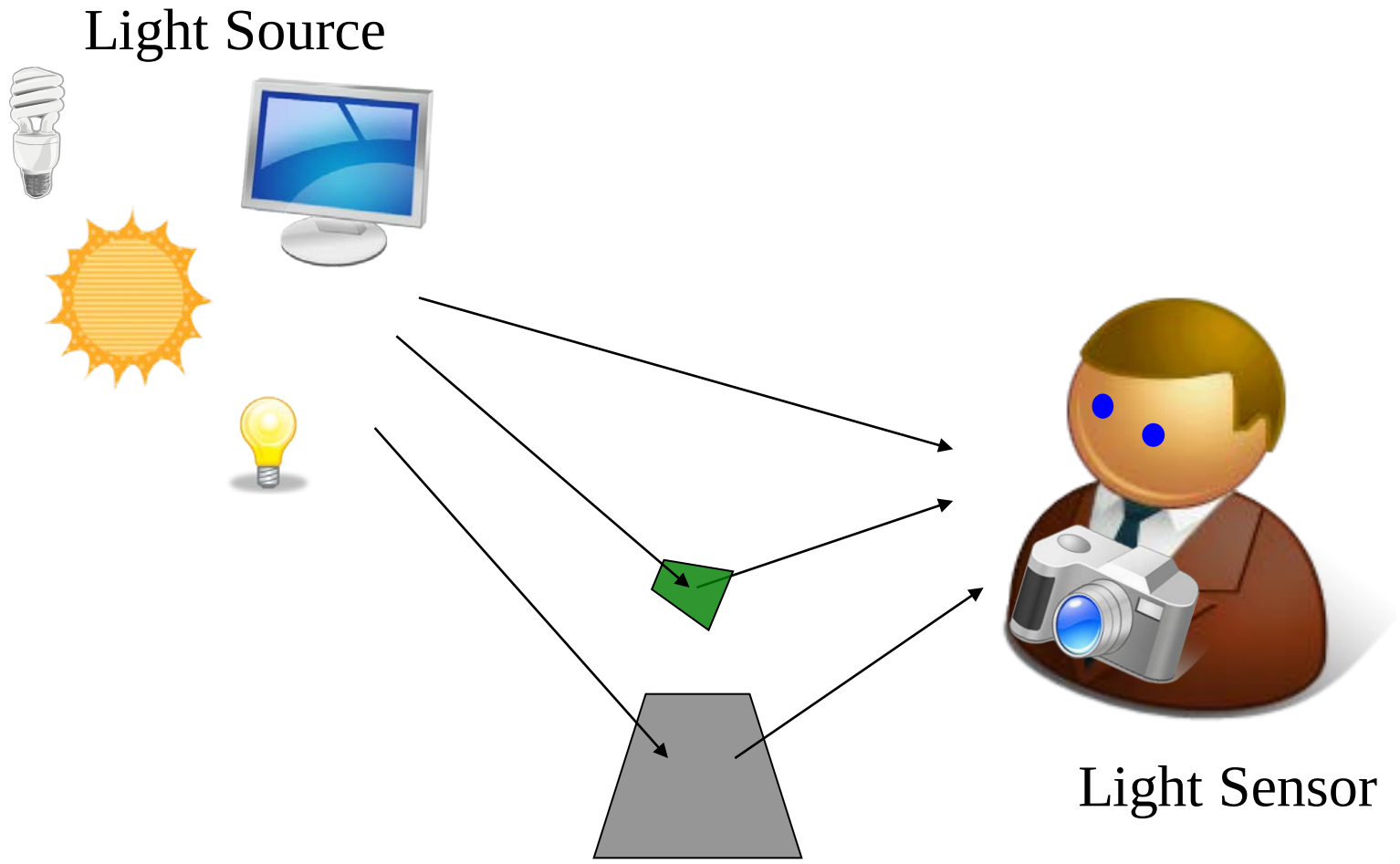
Light Source



Objects

Basics of Color



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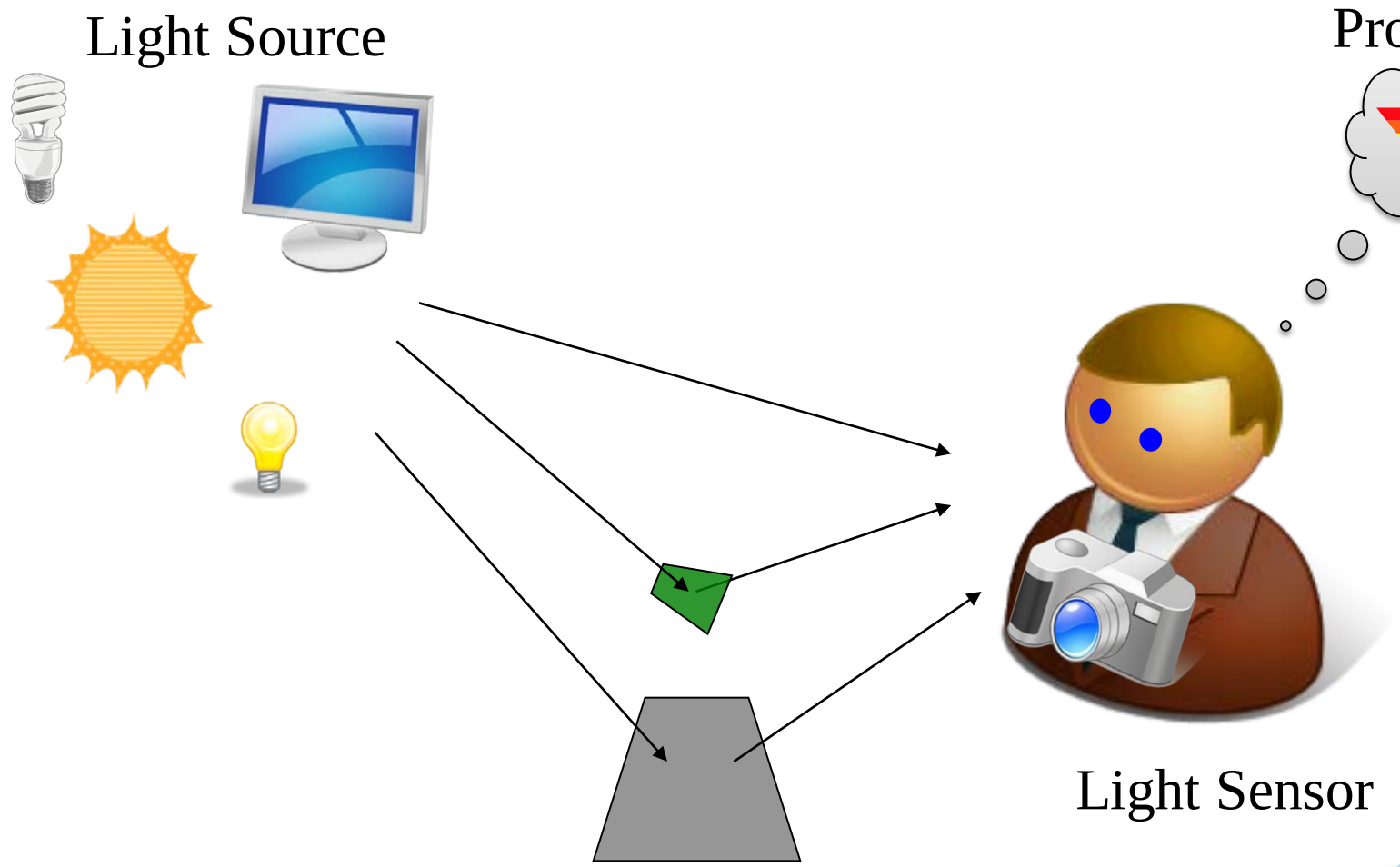

Basics of Color

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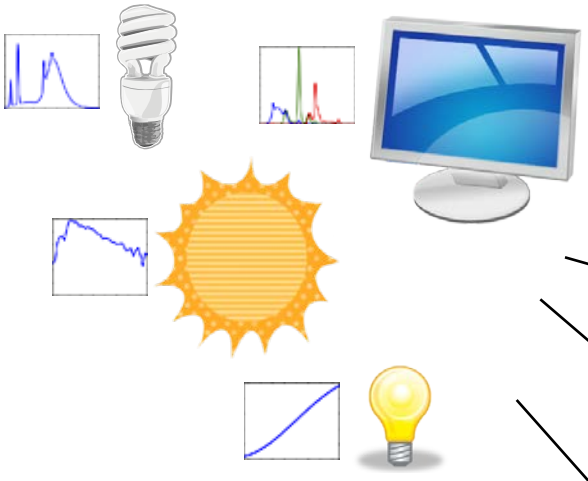
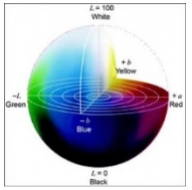
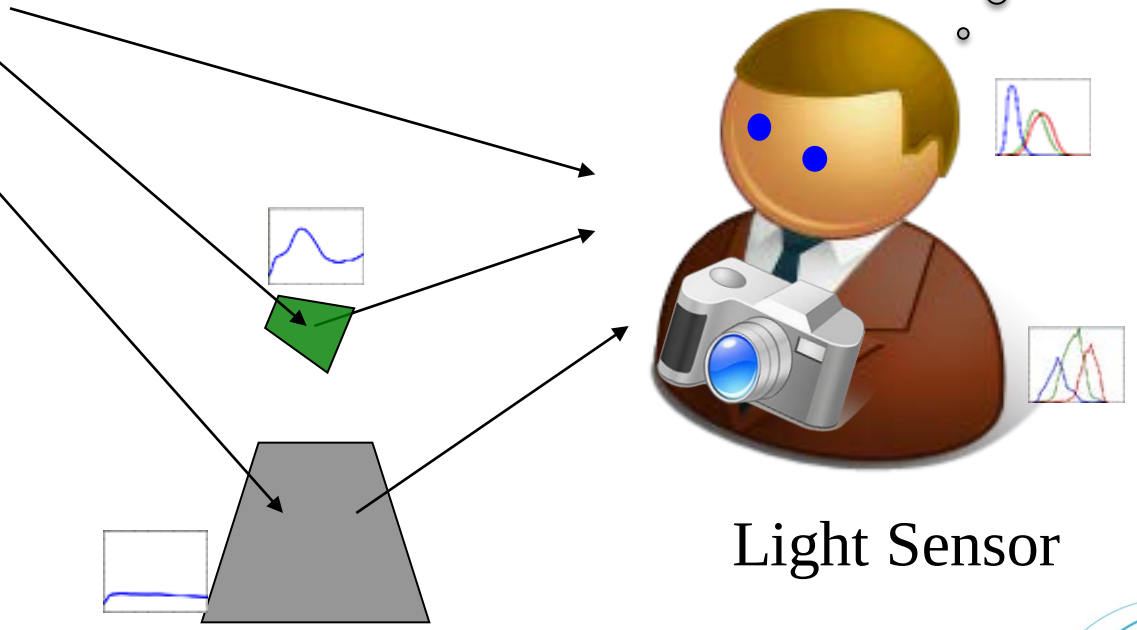


Processing





Light Sensor

Object

Questions related to color

- What is it?
- What is its relationship to light?
- What does it look like?

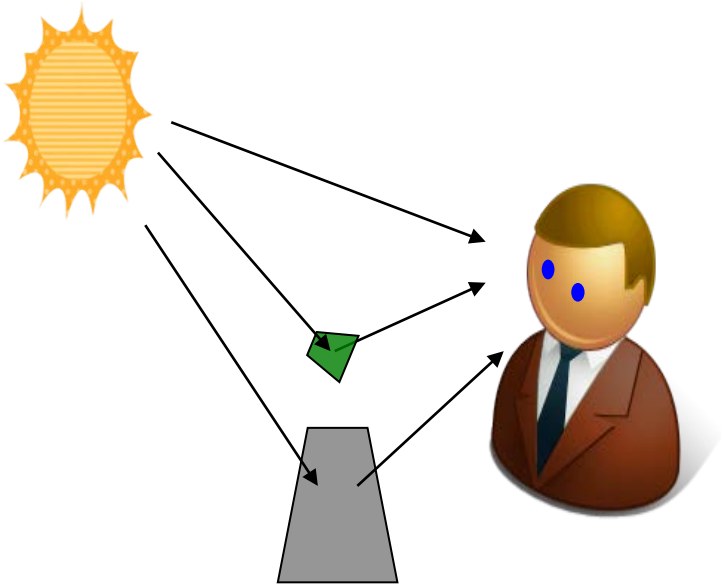
Communicating about Color with ICC

- ICC Profile Specification (ISO 15076-1):
  - v4 ICC profile
  - Defines data container format for color management interchange
  - Color Management Model (CMM) applies transforms from profiles
  - Widely used around the world in many, predominantly graphic arts workflows
  - Widespread adoption in commercial and academic software
  - Very successful at spreading color management to many parts of the world

So why change?

Challenges in "Communicating Color"

- Differences in Light Sources
- Characteristics of Surfaces
- Variations in Observer
- Lighting / Viewing Angles
- Modeling Everything
- Variations in Reproduction Intent
- Keeping things simple



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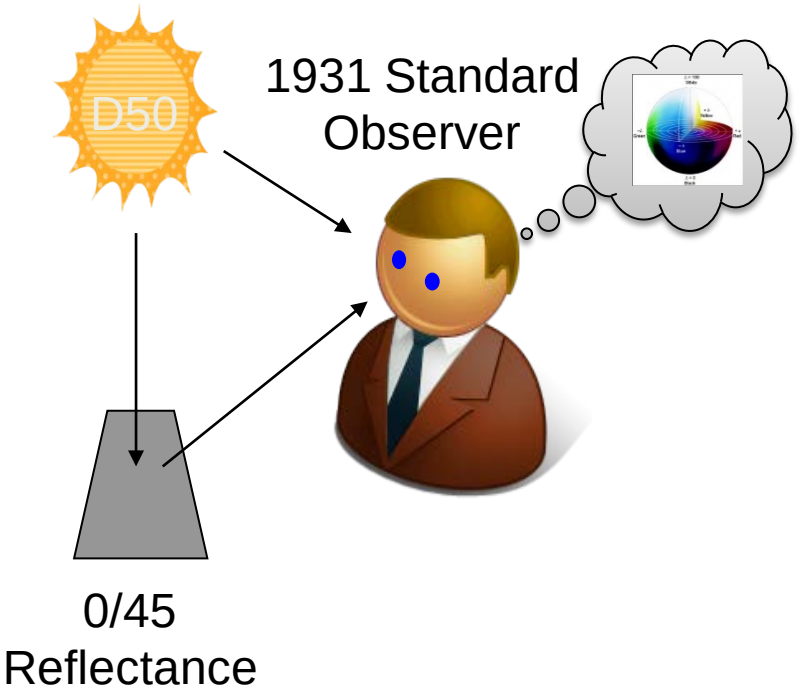
Reasons for Change

ICC v4 only addresses the questions:
"What does it look like?"
"What is it?"

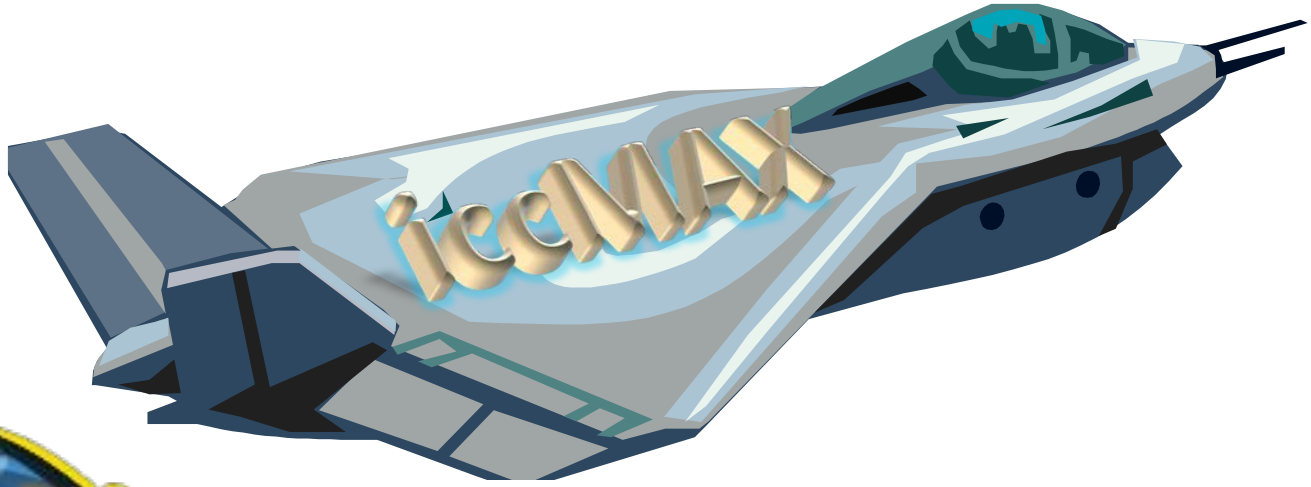


- Basic assumptions of ICC v4 profiles limit applications
  - **D50/2° colorimetric profile connection space (PCS)**
  - **Diffuse uniform illumination and reflectance assumption**
- Structure of ICC v4 unsuitable for some workflows
- Desire to open color management platform and stimulate new development beyond ICC members

Introducing iccMAX

iccMAX takes off where v4 ends…

2 related but different profile formats for different purposes



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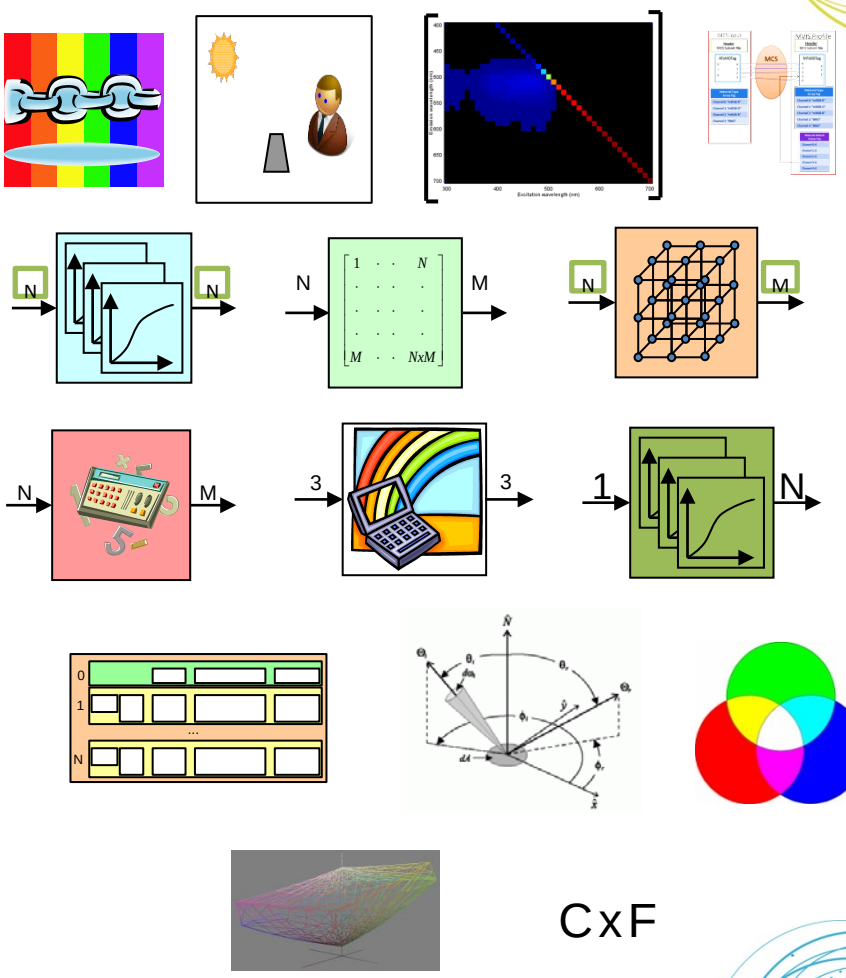
iccMAX vs. v4

- **iccMAX profiles have same header + tag structure as v4 profiles, but:**
  - Different values possible in header.
  - Some retained tag types from v4, some new tag types.
  - Some v4 tag types deprecated.
  - New color space types, PCS types, data tags.

- **iccMAX CMMs generally intended to use v4 profiles, but v4 CMMs will not need to be compatible with iccMAX profiles.**

iccMAX – High Level Overview

- **Connection Space Extensions**
  - Spectral profile header extensions
  - Profile Connection Condition (PCC) tags
  - PCS Transforms
  - Sparse matrix encoding
  - Material Connection Spaces
- **multiProcessingElements**
  - 1-D Look Up Tables (LUTs)
  - Matrices
  - N-dimensional LUTs
  - Calculator element
  - ICC Color Appearance Model element
  - Tint Array element
- **Hierarchical tag types**
  - nameColor, colorantInfo, measurementInfo, profileInfo
  - Support for angular dependencies via Bidirectional Reflectance Distribution Functions (BRDF)
- **Other Extensions**
  - Color Space Encoding profiles
  - Gamut Boundary Description encoding
  - *Color Measurement (CxF) tag encoding*
  - *UTF8 text & UTF16 encoding*
  - *Additional Numeric Array Types*



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About iccMAX Workflows

- **iccMAX profile encoding is defined by iccMAX specification**
- **iccMAX workflows are defined by iccMAX Interoperability Conformance Specification (ICS) documents separate from the iccMAX specification**
  - ICS documents define workflow specific requirements utilizing features of iccMAX specification
  - ICS documents will be registered with the ICC for defining various domain specific workflows
- **Not every feature of iccMAX specification needs to be implemented to support an iccMAX based workflow**
- **Allows for future iccMAX extensions**
- **ICC is providing a reference implementation of an iccMAX V5 CMM**

iccMAX and Real World Scenarios

1. Packaging
2. Hifi Color Printing
3. Soft Proofing

Scenario 1 - Packaging

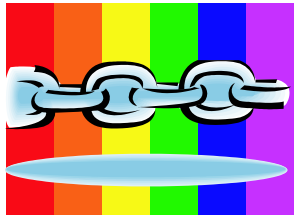
- Color is used to attract buyer attention and establish and maintain brand awareness
- Consistent appearance across product, packaging, shipping, and point of sale advertisements is extremely important
- Packaging crosses multiple output production and manufacturing processes and providers
- Color communication is “Critical”

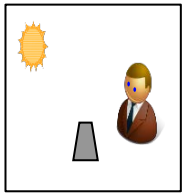
Packaging CM Challenges

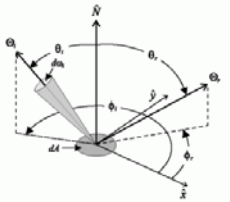
- Packaging crosses multiple output production and manufacturing processes and providers
  - Different processes make color differently
  - Everyone needs to agree on color description
- Cannot communicate color using “simple appearance”
  - Appearance changes under different lighting/viewing conditions
  - Specialty inks/colorants
    - Metallics
    - Fluorescence
  - The final lighting condition varies and is unknown
- ICC.1 Named color profiles only communicate “simple appearance” for 100% solid colors

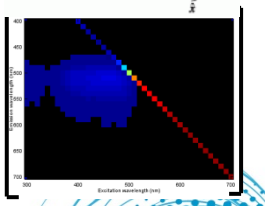
Packaging and iccMAX

- iccMAX uses a completely new Named Color Profile Architecture
  - Multiple tints for each named color
  - Can define various interactions with light
    - Spectrally based Measurements (over white/black) provide input to a Spectral Profile Connection Space (PCS)
    - Measurements over multiple measurement geometries
    - Colors can be defined to account for lighting and observer angles using BRDF
    - Fluorescence (where surface transforms light from one wavelength to another) can be characterized
  - Uses expandable hierarchal encoding that allows for possible future needs to be addressed
- iccMAX Named color profiles can be used with other iccMAX profile classes in color workflows



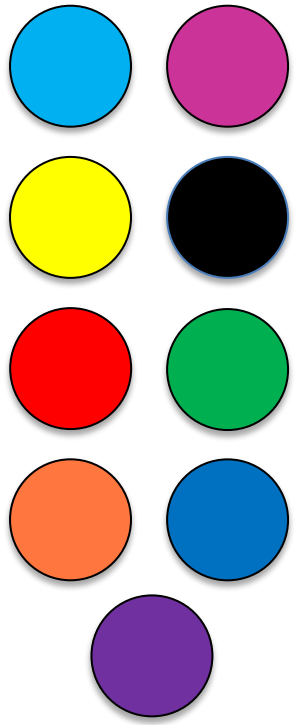






Scenario 2 – Hifi Color

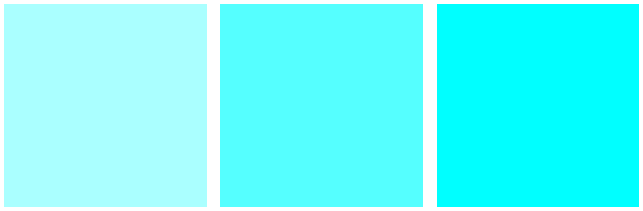
- Using more than four channels (CMYK) as an input process color space (HIFI Color) for Color Management
  - In press:
    - Allows for a wider gamut
    - Direct spot color matching
    - Wide variety of jobs can be printed without changing ink sets
  - Emulation:
    - Overprint (print order) behavior of emulated spot channels can be defined by profile



Hifi CM Challenges

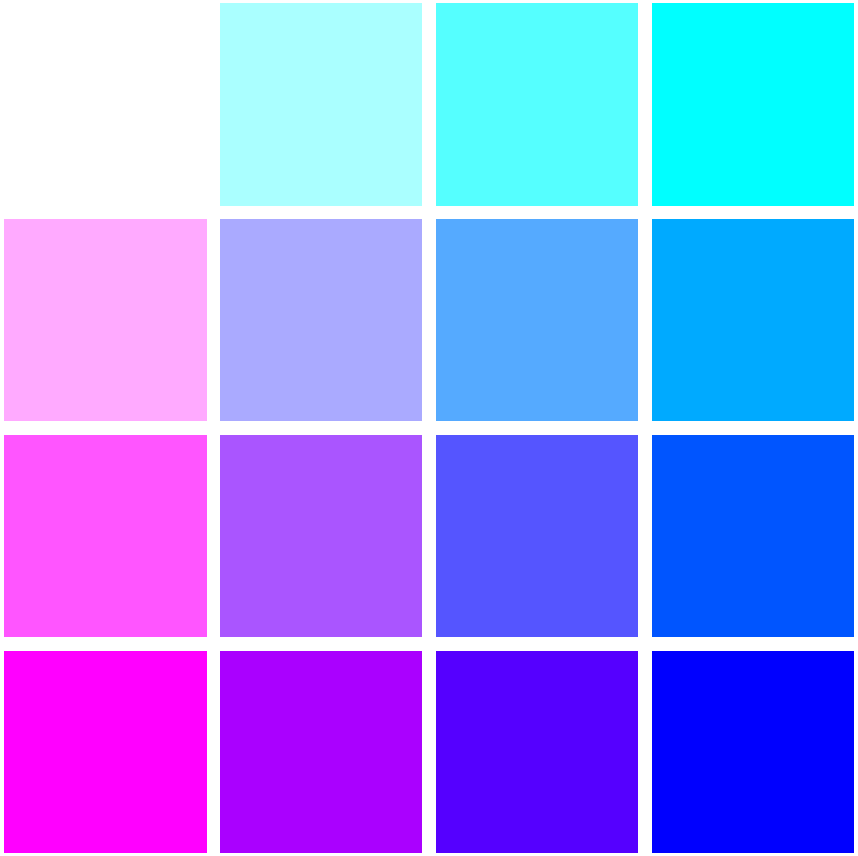
- Connecting profiles by device channels requires that the order and number of channels match exactly
  - What if first profile uses different order or some channels are not used?
- V4 ICC color profiles encode color transforms for N-channel device input using N-dimensional look-up tables
- N-dimensional look-up tables (LUTs) grow in size at an exponential rate (that is prohibitively large)

Example of Exponential Table Growth



- Colors:
  C
- Sampling:
  0, 33, 66, 100%
- LUT Size
  4

Example of Exponential Table Growth

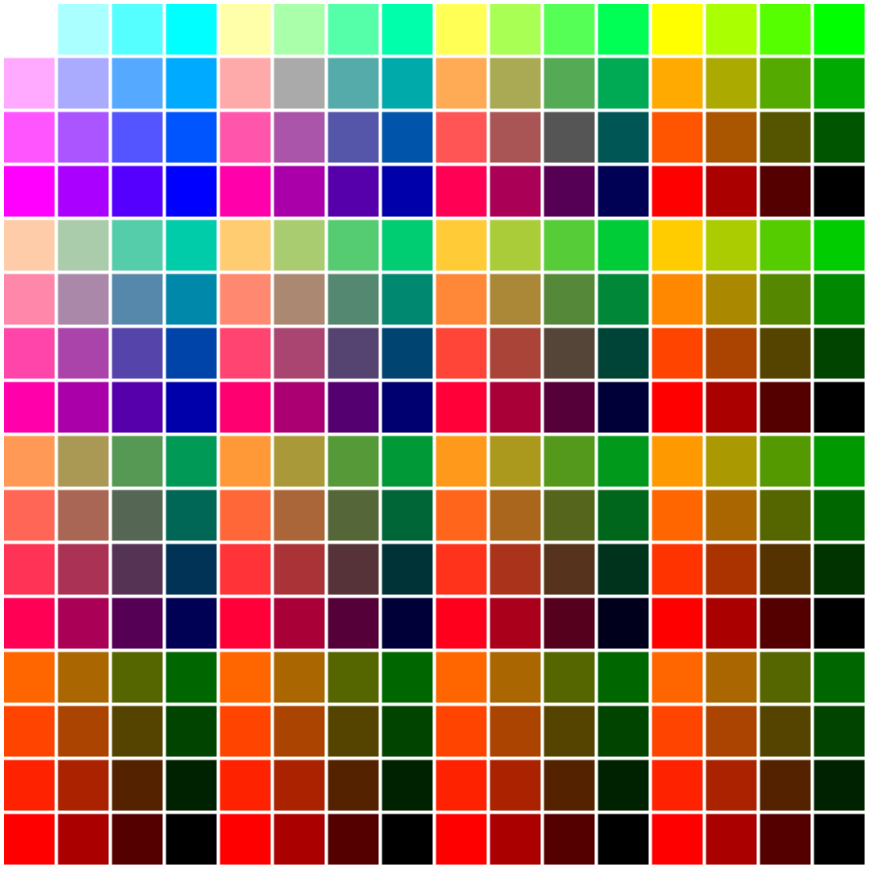


- Colors:
  - CM
- Sampling:
  - 0, 33, 66, 100%
- LUT Size
  - 4x4=16

Example of Exponential Table Growth

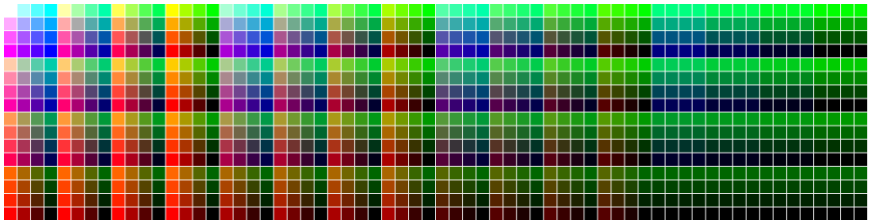
- Colors:
  CMY
- Sampling:
  0, 33, 66, 100%
- LUT Size
  4x4x4=64

Example of Exponential Table Growth



- Colors:
  CMYO
- Sampling:
  0, 33, 66, 100%
- LUT Size
  4x4x4x4=256

Example of Exponential Table Growth



- Colors:

  CMYOG

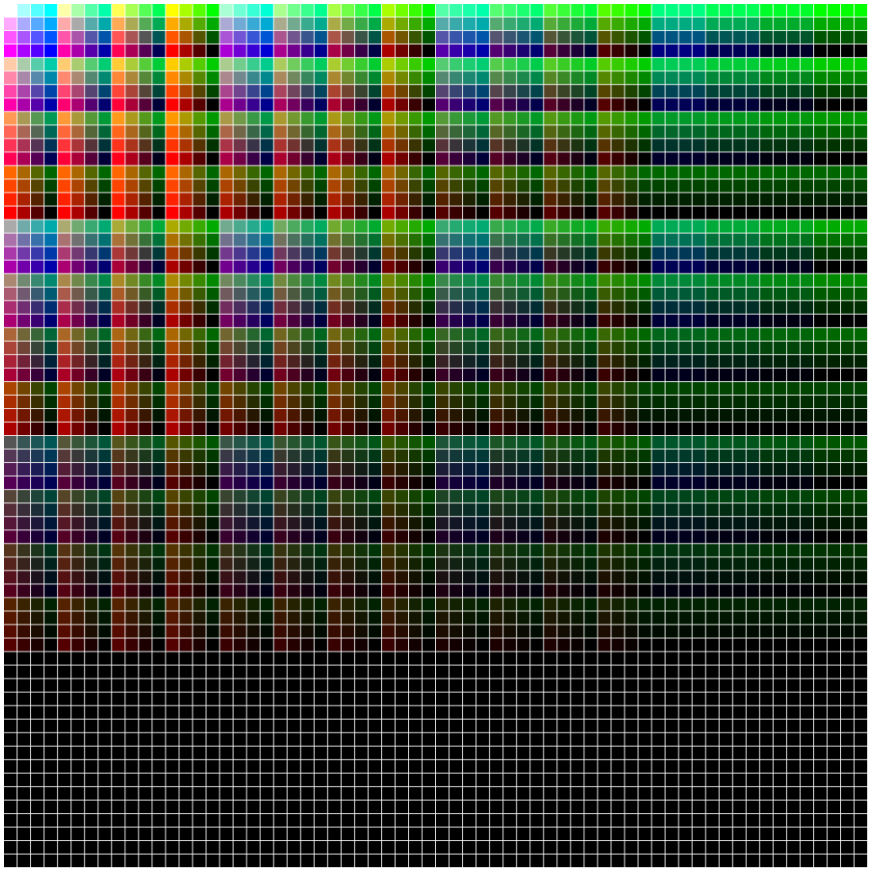
- Sampling:

  0, 33, 66, 100%

- LUT Size:

  4x4x4x4x4=1024

Example of Exponential Table Growth



- Colors:

  CMYOGK

- Sampling:

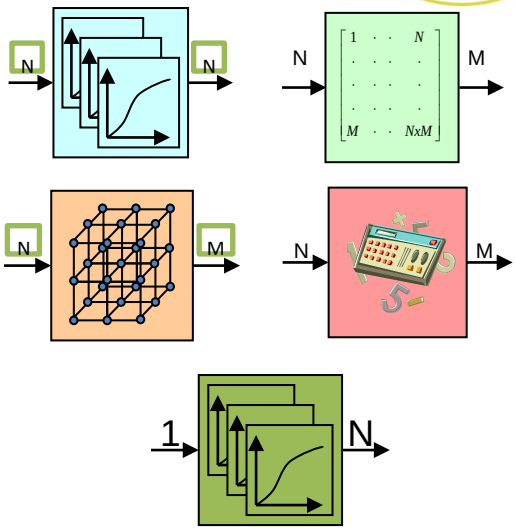
  0, 33, 66, 100%

- LUT Size:

  4x4x4x4x4=4096

Hifi Color and iccMAX

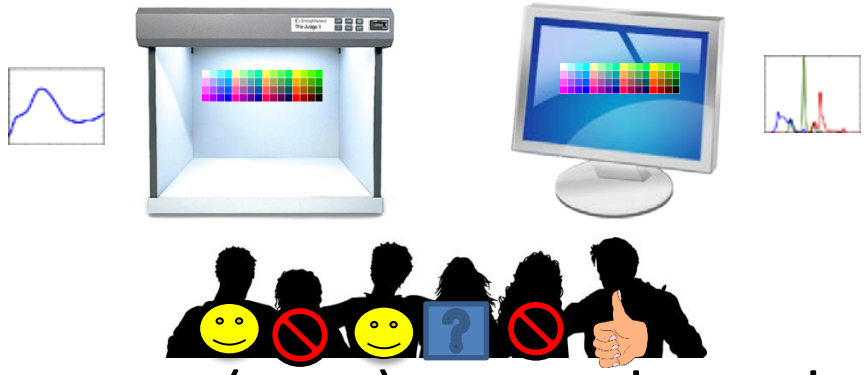
- iccMAX utilizes transforms defined by the MulitProcessElements tag type
  - A programmable transform mechanism
  - Can conditionally apply lower dimensional LUTs
  - Can directly encode device models
  - Can directly encode overprinting models
- Material Connection Space provides flexible routing for device like channel connections



Scenario 3 – Soft Proofing

Make image on display appear the same (match) an object under some lighting condition

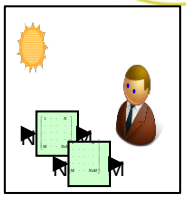
Soft Proofing CM Challenges

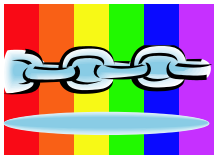


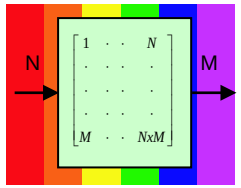
- Impossible to get (near) spectral match
  - Surfaces have smooth spectral reflectances
  - Displays have sharp spectral characteristics
  - Only a match of cone excitations (appearance) is possible
- There is variability in sensitivity functions of observers due to age (lens yellowing) and cone pigment encoding
  - Cone excitations of actual observers therefore do not match the “standard observer” (or each other)

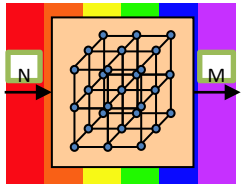
Soft Proofing and iccMAX

- iccMAX introduces the concept of Profile Connection Conditions (PCC) that provides
  - Observer specific color matching functions
  - Spectral power distribution of illuminant
  - Conversion transforms to/from standard observer and D50 illuminant colorimetry
- PCC can be applied with spectrally defined processing elements in connected profiles to achieve colorimetric match for actual observer









What lies ahead …

The Future and iccMAX

- iccMAX provides new opportunities and new challenges while addressing color challenges of today
- iccMAX allows color management approaches to be applied in new ways by new industries
- However, those happy with ICC v4 may have no need for iccMAX

IccMAX Challenges and Opportunities

- Provides new ways to communicate about color
- New technologies enabled or required
- New color measurement technology needed
- New standards will be established
- Enables new industries to engage in color management

Industries that can possibly benefit

- Medical Imaging
- Fine Art Reproduction
- Motion Picture and Video Industries
- Academic Research
  - Color Science
  - Vision Science
- Industrial Color
- Lighting

In Conclusion …

iccMAX for the Real World

- Color in the “Real World” is much more complex than what can be communicated using ICC v4 profiles
- iccMAX communicates answers to the color questions
  - What is it?
  - How does it interact with light?
  - What does it look like?
- iccMAX provides a flexible platform for modeling and defining color workflows
- iccMAX encompasses the complexities of color in the Real World

Thank You

Questions?