Making A Future
with Color Management

THE INTERNATIONAL CONFERENCE

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NPES ICC THE STATE POLYTECHNIC OF Creative Media

iccMAX: the Next Wave of ICC Color Management

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Overview

- **Background and motivation for iccMAX**
- **Overview of some important iccMAX features**
- **iccMAX Workflows**
- **Current status of iccMAX**
- **Summary**

ICC Profile Specification

- **ISO 15076-1:**
  - —v4 ICC profile
  - —Defines data container format for colour management interchange.
  - —Widely used around the world
  - —Predominant in graphic arts workflows.
  - —Widespread adoption in commercial and academic software.
  - —First published as ISO standard in 2005.
  - —Very successful at spreading colour management to many parts of the world.

What is v4 Good For?

- Enabling cross-platform, vendor-neutral consistent colour in graphic arts applications**.**
- Connecting any device or colour space through a well-defined Profile Connection Space (PCS)
- Viewing and colour matching under standard lighting conditions similar to D50.
- Enabling colour tuning in colour managed workflows.
- Providing standard container for specifying colour interchange.

So why change?

Motivations for Change

- **Basic assumptions of ICC v4 profiles limit applications**
  - **D50/2° colorimetric PCS**
  - **No support for spectral data or transforms**
  - **Diffuse uniform illumination assumption**
  - **Simple transforms are effectively limited to low dimensionality**
- **Structure of ICC v4 unsuitable for some lightweight workflows.**
- **Desire to open colour management platform and stimulate new development beyond ICC members.**

iccMAX key changes

- **Wider range of Profile Connection Spaces, e.g.**
  - **Colorimetry**
  - **Spectra**
  - **Material**
- **Wider range of transforms**
  - **Complete flexibility with Multi-processing element**
- **Wider range of tag types**
  - **Gamut boundary**
  - **Measurement data (CxF)**
  - **Extended data types**

iccMAX vs. v4

iccMAX takes off where v4 ends…

2 related but different profile formats for different purposes

iccMAX

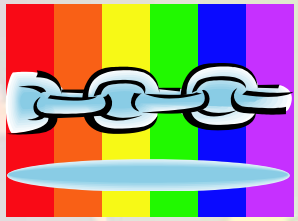
iccMAX vs. v4

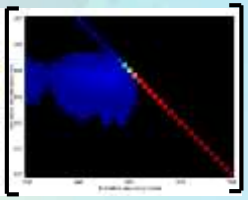
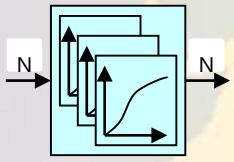
- **iccMAX profiles have same header + tag structure as v4 profiles, but:**
  - —Different values possible in header.
  - —Some retained tag types from v4, some new tag types.
  - —Some v4 tag types deprecated.
  - —New color space types, PCS types, data tags.

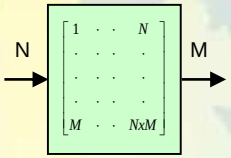
- **iccMAX CMMs generally intended to use v2 & v4 profiles, but earlier CMMs will not need to be compatible with iccMAX profiles**

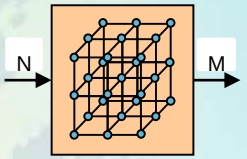
iccMAX – High Level Overview

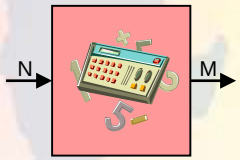
- **Connection Space Extensions**
  - Spectral profile header extensions
  - Profile Connection Condition (PCC) tags
  - PCS Transforms
  - Sparse matrix encoding
  - Material Connection Spaces
- **multiProcessingElements**
  - 1-D Look Up Tables (LUTs)
  - Matrices
  - N-dimensional LUTs
  - Calculator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

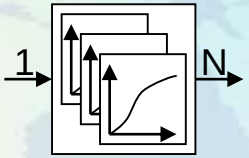


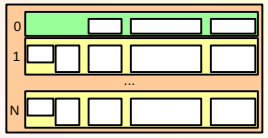



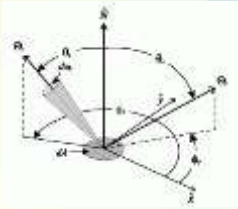
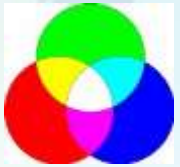











CxF

Note: There is a lot to iccMAX but only basics will be covered in this presentation

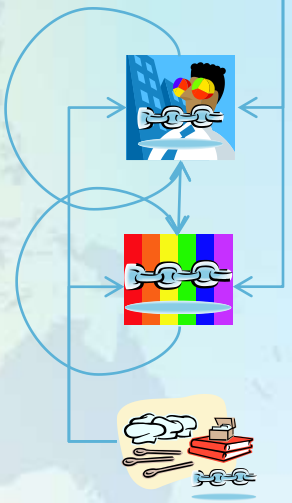
iccMAX Colour Spaces

- **Color space signatures as defined in ICC.1**
- **N-channel color space signatures supporting up to 65535 channels**
- **Colorimetric Profile Connection Spaces**
  - Same as defined in ICC.1 (XYZ and L*a*b*)
  - Observer and Illuminant can vary as defined by spectral viewing conditions tag
- **Spectral Profile Connection Space Signatures**
  - Reflectance, transmission, radiant/emission spectra, and bi-spectral (fluorescent) spectra (optionally compressed)
  - Additional fields in profile header provide spectral range information for spectral connection spaces

- **Material Connection Spaces**
  - Defines named “material” channels for connection and routing between profiles with default behavior for sub-set channel connection

iccMAX Profile Connections

1. **Named Color connections**
   - — Tint based colors using device, colorimetric, spectral, and/or Bi-directional Reflectance Distribution Functions (BRDF) values
2. **Colorimetric Connections**
   - — How does an observer see it?
3. **Spectral Connections**
   - — What is its relationship to light?
4. **Material Connections**
   - — What is it?
5. **BRDF Connections**
   - — Considering angular dependencies



- **Both Colorimetric and/or Spectral PCS connection tags can be defined in the same profile**

Profile Connection Conditions (PCC)

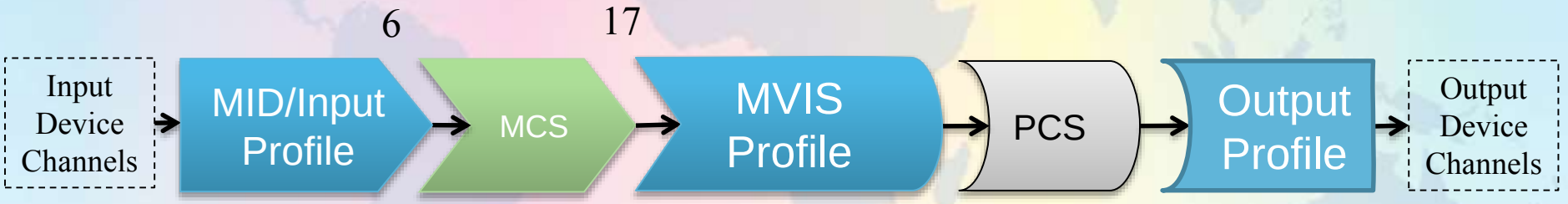
- **Profile Connection Condition (PCC) information is required whenever PCS is NOT standard D50 using 2-degree observer**
  - Provides for interoperability to connect with arbitrary observer / illuminant viewing conditions
  - Provides flexibility for when and how PCS conversions are made
  - Provides colorimetric conversion transforms for changes in observer and / or illuminant
- **Profile Connection Conditions (PCC) comprise of:**
  - Header color space and spectral PCS metadata
  - Three new tags:
    - **spectralViewingConditionsTag**
    - **customToStandardPcsTag**
    - **standardToCustomPcsTag**

Material Connection Workflows

- **A Material Connection Space defines a connection for workflows that defines what the colour channels *ARE* rather than *how they look* or are *how they are related to light***
  - New profile types are used to convert between device, MCS, and a PCS values
- **Examples include:**
  - N-Colour Ink Overprint Visualization
    - Visualizing overprinted ink channels with different ink orders or use of spot inks
  - Fine Art Pigment Identification
    - Going from Multi-spectral capture to Pigment identification to Visualization of pigments
  - Medical imaging
    - Scanning to RGB + extra channels that provide bio-marker information for visualization of slide scan with bio-markers

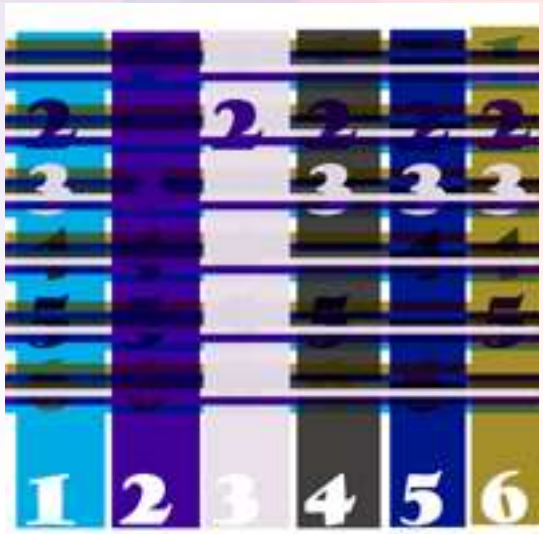
MCS Connection Workflows

MCS Connection Workflows



MID Channels

1. Process Cyan
2. Violet
3. White
4. Process Black
5. Blue
6. Gold

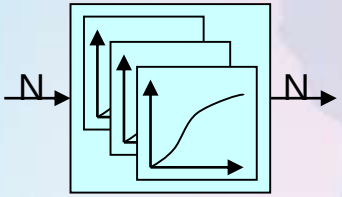


MVIS Channels

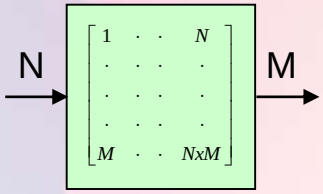
1. Process Cyan
2. Process Magenta
3. Process Yellow
4. Process Black
5. Orange-Yellow
6. Orange
7. Gold
8. Blue-Green
9. Purple
10. Blue
11. Bright-Red
12. Pale Yellow
13. White
14. Silver
15. Red
16. Warm-Pink
17. Violet

Processing with multiProcessElements

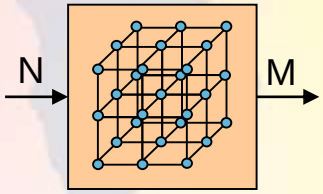
- multiProcessElements are a fundamental part of iccMAX
- They allow for processing workflows to be “programmed” using 32-bit floating point processing
- They completely define transformations from input to output
- Direct colour transformation modeling can reduce profile size and increase accuracy



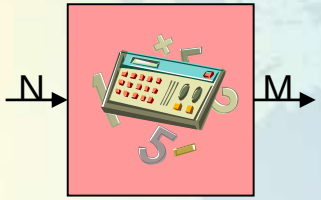
1-D LUTs



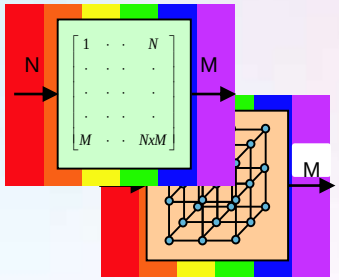
NxM Matrix



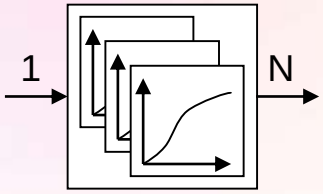
Multi-Dimensional LUT



Programmable Calculator

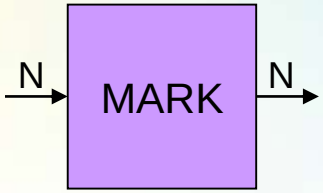


Spectrally Defined Colorimetric



Tint Curves

Colour Appearance Model



Placeholder

The iccMAX Approach

- **Open source development**
  - Reduced risk for individual adopters
  - Improved access to leading research for level playing field
- **Flexible architecture**
  - Different application-specific form factors: not “one size fits all” but “many sizes fit all”
  - Reduced implementation cost for adopters, limited to solutions for particular industries

About iccMAX Workflows

- **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**

Initial Target Markets

- **Packaging**
- **Medical Imaging**
- **Digital Printing**
- **Fine Art**

Status of iccMAX

- **Now available on the ICC Web Site**
  - Preliminary iccMAX specification document
  - Link to open source reference implementation source code on GitHub
  - Binary command line executables to compile, apply, and interact with iccMAX profiles
  - Example profiles and images for various use cases
  - (See: http://www.color.org/iccmax/index.xalter)
- **Various implementations are in the works**
- **Finalizing as an ICC organization standard**
- **In process of ISO standardization**

iccMAX for the Real World

- **Colour in the “Real World” is much more complex than what can be communicated using ICC v4 profiles**
- **iccMAX provides the means to communicate about various approaches to colour**
  - Named Color and Material Connection Spaces (What is it?)
  - Spectral Connection Spaces and BRDF (How does it interact with light?)
  - Extended Colorimetric spaces (What does it look like?)
- **iccMAX provides a flexible platform for modeling and defining colour workflows based on multiProcessElement**
- **iccMAX encompasses the complexities of colour in the Real World**

Thank You

Questions?