N-Color Work at Onyx Graphics

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Outline

• Brief Introduction
• Ways of thinking about N-Color
• N-Color challenges
• N-Color processing and profiling pipelines
• Future opportunities with N-Color
A little bit about Onyx Graphics, Inc.

• Started in December of 1989
• Develops RIP Software for driving wide/grand format printing devices
• Support for
  • Over 2600 print devices
  • Thousands and thousands of combinations of Media+Colorant
• Technologies and applications
  • Aqueous
  • Solvent
  • Latex
  • UV Cured
  • Toner
  • Ceramic glazes
  • Textile Dyes
• Support for lots of different colorants on lots of different media
Why N-Color?

• Extending the gamut of colors that can be reproduced
• Better named color matching (spot emulation)
• Specialty applications
  • White for printing on film/colored media
  • Multi-Layer Printing
  • Draw attention and differentiate
    • Metallics
    • Fluorescence
• Provide competitive advantage
Thinking about N-Color

• At a printer device level
  • N-Color is realized by the ability to have output channels that are independently addressed and controlled

• At a software level
  • N-Color is separated into categories:
    • Process Colors
      • Have implicit color meaning and participate in color management
    • Specialty (spot) colors
      • White, metallics, gloss
      • Directly controlled by the image or document
      • Or job color tools are used to add spot layers
    • Concentrations / dilutions
      • Used to improve effective resolution
      • Can apply to either process or spot channels
Onyx Process Color Spaces

• Internal native numeric conversions can be made between supported process color spaces
• This allows for flexibility in how color management is performed
Establishing relationships between device output channels and software process channels

- Ink Configurations involve
  - Associating ink concentrations with processing channels
  - Associating software processing channels to printer output channels
Profiling process with N-Color

• First step of profiling process uses automated process to define ink concentration separations as processing channels
• Remaining steps only deal with process and spot color channels
• Note: Special care needs to be taken for spot channels that cannot be measured
Challenges of N-Color

• Requires new and wider pathways to work with color pixels
• More information is needed to keep track of things
  • Number of channels is not sufficient
• PDF limitations
  • Source can generally be Grayscale, RGB, or CMYK
  • Complicates transparency processing
• Exponential increase of color combinations (see example)
  • Complicates swatches and n-dimensional look-up tables
• Complicates ink separation and color conversion (see example)
N-Color and PDF

• Problems can occur when using an N-Color output device with PDF
  • Transparency rendering in the device N-Color space is ill defined resulting in undesirable output
  
• Two stage processing can be used to addresses this problem
  • First RIP to a large gamut intermediate CMYK space (Simulation/Proofing) profile for proper rendering
  • Then convert to N-Color using color management

ICC Profile Setup

Source Profile  Intermediate Profile  Intermediate Profile  N-Color Profile
N-Color Dimensional Visualization

• The following slides show the exponential growth of a visual lookup table (LUT) as more dimensions are added
  • The contents of the LUT is visually represented with actual colors for each LUT entry
  • RGB colors are shown rather than Lab, XYZ or spectral values
• Only four steps are represented for each input channel dimension (0%, 33%, 66%, and 100%)
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: $4 \times 4 \times 4 \times 4 \times 4 = 1024$
Example of Exponential Table Growth

- Colors: CMYOGK
- Sampling: 0, 33, 66, 100%
- LUT Size: $4 \times 4 \times 4 \times 4 \times 4 = 4096$
Exponential Growth of N-dimensional LUTs

- In general terms, the number of entry points (E) in a look-up table (LUT) is defined in terms of the number of channels (N) and the number of sampling steps (S) by the exponential equation:

\[ E = S^N \]

- E gets **really big, really fast** for each increase in N.
Multi-dimensional aspects of hue separation

Consider going from Yellow to Magenta
Multi-dimensional aspects of hue separation

Consider going from Yellow to Magenta

Consider going from Yellow to Magenta including Orange
Swatch Generation

- Swatch format selects between N-Color and Extended CMYK profiling approaches

N-Color Profile Generation Settings

- Can use pre-defined ink separation (smooth) or dynamic separation (to maximize gamut size)
**N-Color Output Processing Pipelines**

### CMYK + N-Color Separation
- Uses standard CMYK profiling mechanisms
  - Indicated by using CMYK swatch
- Separate custom CMYK to N-Color separation indicated in profile metadata
- Requires a custom CMM
  - Not an open, vendor neutral, cross platform solution

### Direct N-Color
- Requires N-Color Swatch
  - Indicated by using N-color swatch
  - Less sampling of full color space
- Separation to N-color is part of ICC profile
  - Larger Profile
- Uses standard ICC technology
N-Color Input Processing Pipelines

**CMYK + N-Color Separation**
- Uses standard CMYK profiling mechanisms
  - Indicated by using CMYK swatch
- Separate custom N-Color to CMYK color conversion
  - May not represent actual colors
- Requires a custom CMM
  - Not an open, vendor neutral, cross platform solution

**Direct N-Color**
- Table grows exponentially relative to N
  - Represents actual colors
  - Less sampling of full color space
  - Indicated by using N-color swatch
  - Larger profile or less accurate profile
- Uses standard ICC technology

ICC DevCon 2020
Current Use of iccMAX by Onyx Graphics

- Transforms are encoded in iccMAX using the MulitProcessElements tag type which provides a programmable transform mechanism.
- Currently Onyx uses iccMAX to change the LUT color space to improve interpolation accuracy of output Tables.
The Future of N-Color with iccMAX

- Options for determining output values from N-dimensional input values include:
  - Algorithmic:
    - Conditionally selecting and applying lower dimensional LUTs with higher sampling
      - Example: CMYK-3DLUTs.icc
  - Computational:
    - Directly encoding device/colorant math model
      - Example: ElevenChanKubelkaMunk.icc
    - Directly encoding of overprinting math model
      - Example: 17ChanWithSpots-MVIS.icc

- Note: The above examples can be found in RefIccMAX
Thank you for your kind attention!

Questions?