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**Color Management and
need for extending standards
to solve problems for device output and print**

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**Some intentionally simplistic thoughts about
ICC based color handling from a
graphic arts/printing industry point of view...**

Core aspects of ICC based color handling

- main goal: make digital color data visible
- ICC principle is a one-trick-pony:
source > PCS > destination
- this principle is used for all kinds of purposes
 - display on monitor
 - drive printer
 - simulate printer output on monitor
(or other printer)
 - convert to some other color space
(e.g. a working, compositing or
blending color space)

Conversions

- non-destructive:
 - for display/print output
 - never more than one (straight to output) or two (simulate) on-the-fly conversions
- destructive:
 - save color data in a different color space
 - limited precision of computation (rounding)
 - limited bit depth (quantization)
 - clipping due to gamut (for colorimetric conversions)
 - info about source color space lost (gray/RGB/CMYK)
 - for CMYK source: black generation info lost
 - repeated conversions increase loss of information

ICC: Focus on color appearance

- optimize for color appearance
- works well (in terms of quality and efficiency) within limitations of devices
- tends to neglect quality of information
- mainly an issue with CMYK output for presses:
 - black text gets “fuzzy”
 - “contaminated” colors for vector objects
 - gray scale images end up separated into 4c

What is “quality of information”

- resolution, amount of detail



- unambiguousness, absence of fuzziness



Quality of information versus color appearance

- major portions of printed content are ‘consumed’ mostly for their information (just think text...)
- some content requires color to carry information but not necessarily perfect color appearance (e.g. maps, business graphics)
- for (color) images though color appearance is much more important
- for any content color appearance adds major value (e.g. corporate colors, branding, fashion, catalogs ...)
- Nevertheless:
 - Quality of information almost always takes precedence over color appearance
 - Or worded differently: color appearance can never be more important than quality of information

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Revert to device color and (selectively) skip ICC color handling?

- control CMYK colorants by use of device color spaces:
- workaround for text: DeviceGray, DeviceCMYK, Separation Black
- workaround for colored vector objects to avoid contaminated/fuzzy appearance: combination of colorant values using DeviceCMYK, DeviceN
- convert grayscale images to destination process using DeviceGray or Separation Black
- this approach implies an ‘early binding strategy’ and practically sacrifices device independence

Revert to device color and (selectively) skip ICC color handling?

- inherent problems:
 - pre-visualization of print results undefined
 - process conversions (repurposing for a different output process) – whether by CMYK→PCS→CMYK conversions or by device link profiles – require assumptions

Revert to device color and (selectively) skip ICC color handling?

- PDF/X OutputIntent – a step in the right direction?
- supports pre-visualization (proofing), but PDF specification & PDF/X standard do not offer sufficient foundation for repurposing
- Still unsolved:
 - tone value adjustments for repurposing device color destined for a different printing press process (necessary to maintain quality of information)
 - this applies to tint values for vector objects as well as to grayscale images

How to address issues?

- any color must be fully characterized at anytime
- it must be possible to request tone values of a device colorant (of a specific printing process)
- for device colorant requests color conversions must not be done through PCS, but by means of tone value adjustments (unless the destination color space uses different colorants/a different type of color space)
- this may be easy for single object documents (e.g. images in an image editing application), but
- this needs to be supported in multi-object documents created by content aggregation applications (like graphics or layout programs)

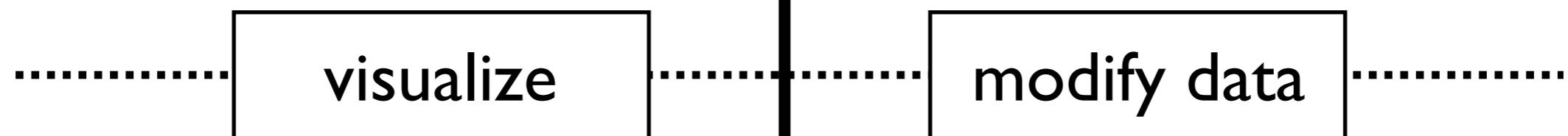
How to handle device specific (CMYK) color?

- any device colorant requests (intended for a CMYK printing process) must be made on the background of a color space
- that is colorimetrically defined by means of an ICC profile and
- for which the applicable TVI curves for each colorant are known
- pre-visualization as well as conversion to non-CMYK spaces use the ICC profile
- conversion to other CMYK spaces uses TVI adjustments
- support necessary in authoring applications as well as color converters and output systems/workflows

Suggestion for structuring color handling

characterized (based on CIE model)
• use ICC based conversion

destination other than CMYK:
• use ICC based conversion



no characterization
• assumptions required
• color display/output is typically driven by setup, not by color data

destination is CMYK – handle specifically:
• objects where color appearance is key
• objects where quality of information is key

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modify data

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Suggestion for structuring color handling

all objects are characterized:
• use ICC based conversion

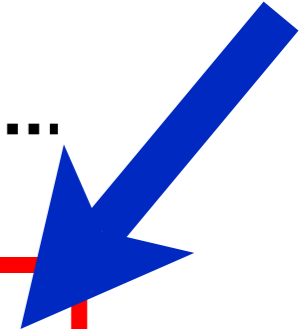
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~~no characterization~~
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Six necessary steps

- the suggested steps only apply to CMYK destinations (and possibly other future multi-colorant printing processes, e.g. Hexachrome)
- interoperability with non-CMYK destinations
 - whether for conversion or for display/simulation – is not reduced, but instead substantially optimized

Necessary steps (1)

- require output intent for each document that (possibly) needs control over device colorants in a CMYK process
- output intent must consist of
 - CMYK output profile
 - information about tone value increase (might be a matching grayscale profile)

Necessary steps (2)

- introduce a new rendering intent “MaintainColorants”
- this rendering intent essentially demands to only do tone value adjustments per colorant channel, and only for CMYK (or any of its colorants) and only for CMYK destinations

Necessary steps (3)

- adjust PDF specification and PDF/X standard such that
- for display/pre-visualization/proofing as well as for any non-CMYK destination an ICC based conversion is used
- for conversion to any CMYK destination, if and only if rendering intent is set to “MaintainColorants”, only adjust tone values (based on difference between source and destination TVI curves), otherwise do an ICC based conversion
- a similar strategy should be added to the PostScript specification

Necessary steps (4)

- vendors of authoring applications for professional graphic arts users extend their programs such that
 - an output intent (CMYK profile and TVI curve) is associated with any document that uses CMYK
 - a user may choose which (CMYK) objects shall use the “MaintainColorants” rendering intent (document policy based on objects types, object by object)
 - write output (PostScript/PDF) accordingly (including output intent and rendering intent)

Necessary steps (5)

- vendors of authoring applications not targeted at professional graphic arts users (e.g. office) extend their programs such that
 - an output intent (CMYK profile and TVI curve) is associated with any document that uses CMYK
 - a policy is used, that applies “MaintainColorants” at least for text and possibly for certain vector objects
 - write output (PostScript/PDF) accordingly (including output intent and rendering intent)

Necessary steps (6)

- Due to the size of CMYK output profiles (0.5 to 2 MB):
- standardize (at ICC or ISO) a basic set of output conditions, including TVI curves, for main printing conditions (characterization data as registered at www.color.org not sufficient)
- establish a software-readable/-accessible Internet registry of output intents (CMYK profiles+TVI curves)
- extend OutputIntent in PDF specification and PDF/X such that it may refer to a destination profile and TVI curve by means of a URL (via http is preferred)

Additional work ahead...

- Spot colors also need to be addressed:
 - ISO TC 130 needs to standardize process control for spot color printing, and also has to
 - establish a standardized way of communicating solid ink aim values (Lab) per spot color depending on substrate, as well as
 - of communicating a representation for intermediate tint values (linear interpolation of tint values for spot colors often does not work sufficiently well)

Thank you for your attention !