Printer Ink Limit Optimization

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How can a limit for ink saving be determined that does not affect print quality

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Problem Definition

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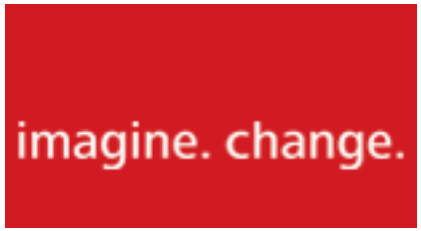
How low is the ink limit too low to have an acceptable color quality?

- Customers would like to reduce ink/toner usage with minimum loss of color quality
- Manufacturers would like to boost ink usage
- Printers normally have a ink limit below 300%
  - Dryer or ink, other mechanical, paper problems
  - Customers way of reducing ink coverage on a page

Ricoh Ink/toner Optimization Technology



- There could exist multiple sets of printer CMYK values that produce the same/similar CIELab color
- Ricoh technology:
  - Creating an accurate color conversion model
  - Conducting a search algorithm to find many possible CMYK combinations
  - Choosing the CMYK value to satisfy the requirement

Ricoh Ink/toner Optimization Technology

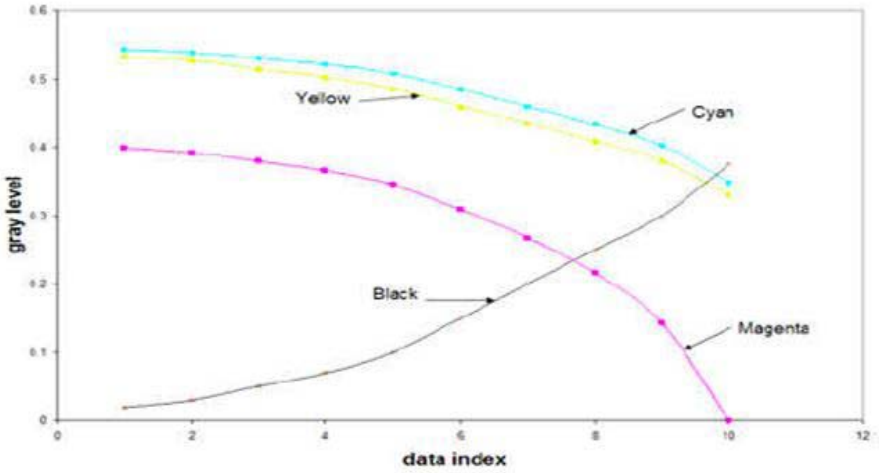


Figure 5.1: The level set of CMYK values for $CMY = \{0.55, 0.4, 0.55\}$.

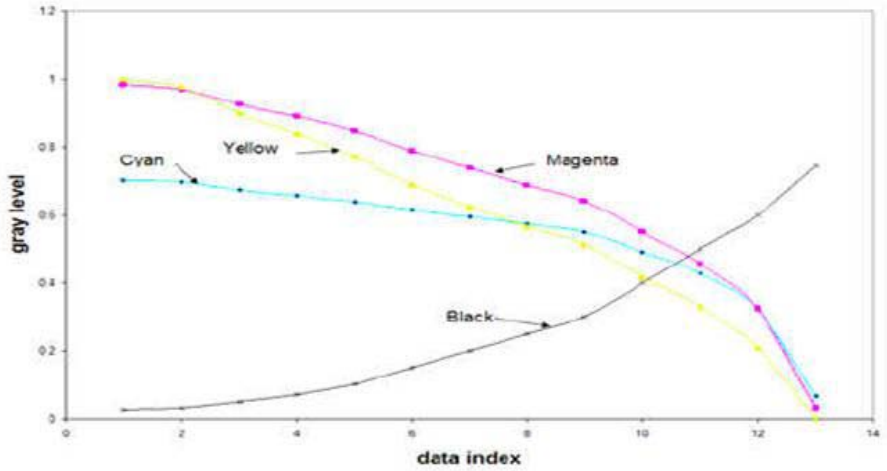


Figure 5.2: The level set of CMYK values for $CMY = \{0.7, 1.0, 1.0\}$.

For CMY=[55 40 55 0], total150% coverage

- 10 sets of CMYK values have the same appearance
- Minimum ink coverage is [35 0 33 37] total 115%
- Ink saving 45%

For CMY=[70 100 100], total 270% coverage

- 13 sets of CMYK values have the same appearance
- Minimum ink coverage is [3 7 0 74] total 84%
- Ink saving 186%

Printer color conversion with an ink limit

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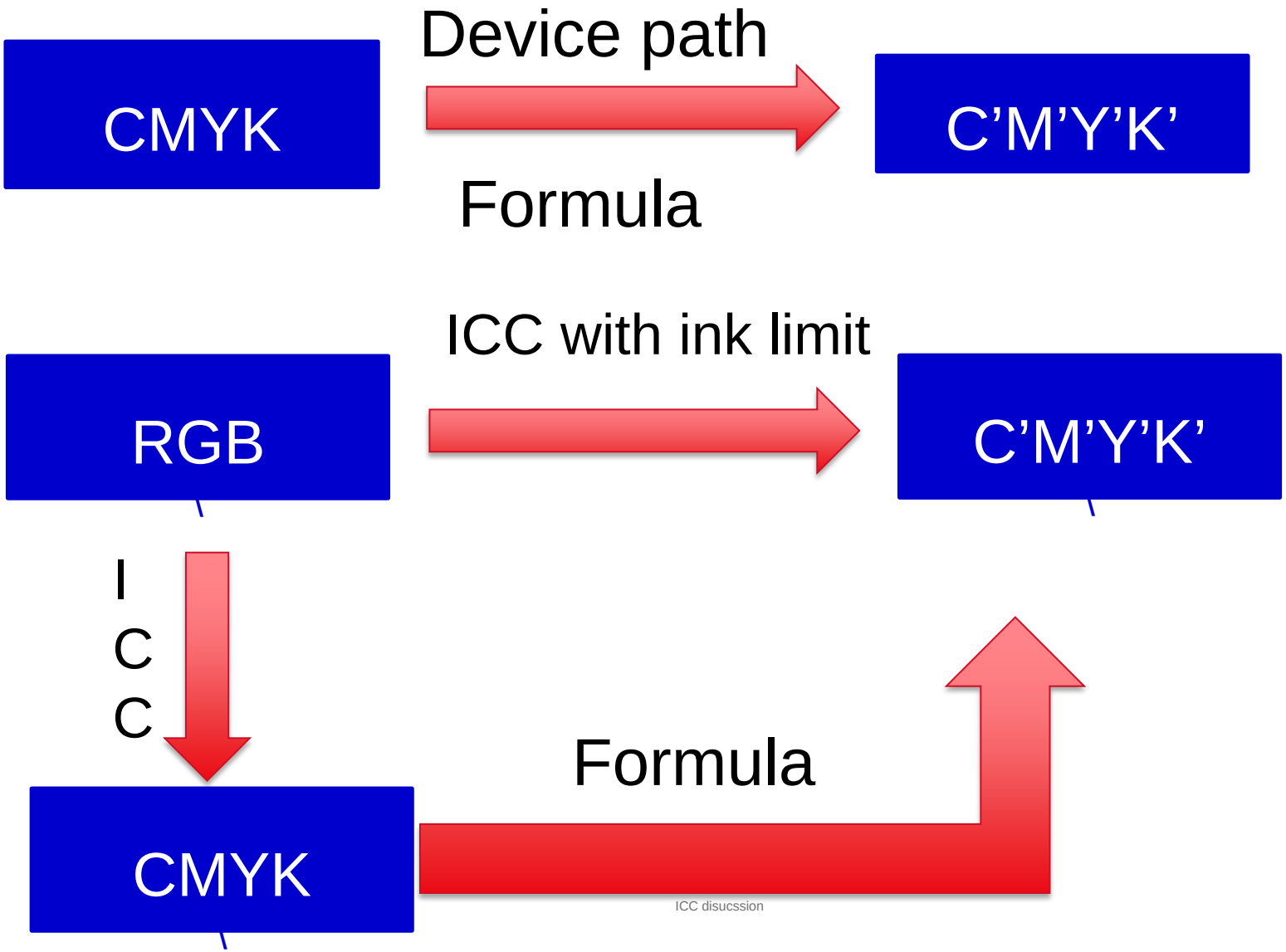

Ink/toner Optimization for Printers with Ink/toner Limit

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- Can the technology maximize the color capability for a printer with ink/toner limit?
- With the help of the technology, what's the minimum ink limit is acceptable for an acceptable print quality?

Experiments

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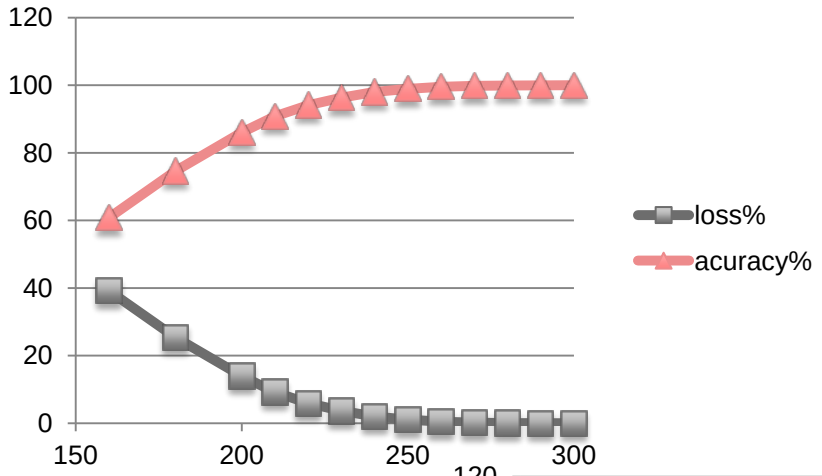
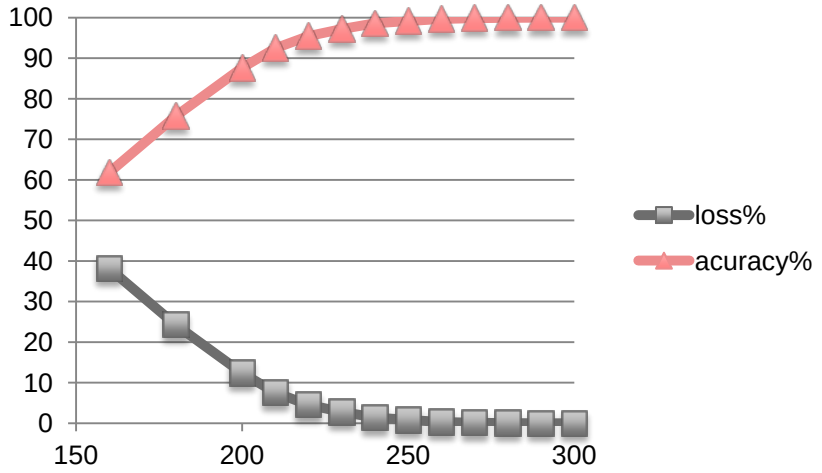
- RPPS ink/toner optimization technology was experimented on three printers:
  - Production cut sheet EP printer
  - Production continuous form inkjet printer
  - High end desktop inkjet printer
- Create CMYK to Lab conversion table 17^4
  - Calculate % of CMYK values that exceed the ink limit. E.g., 60% colors above 160% ink limit
  - Apply Ink optimization method to the colors over the ink limit
  - Replace the original CMYK value above the ink limit with reduced C'M'Y'K' that below the ink limit
  - Calculate % of CMYK values that exceed/not exceed the ink limit

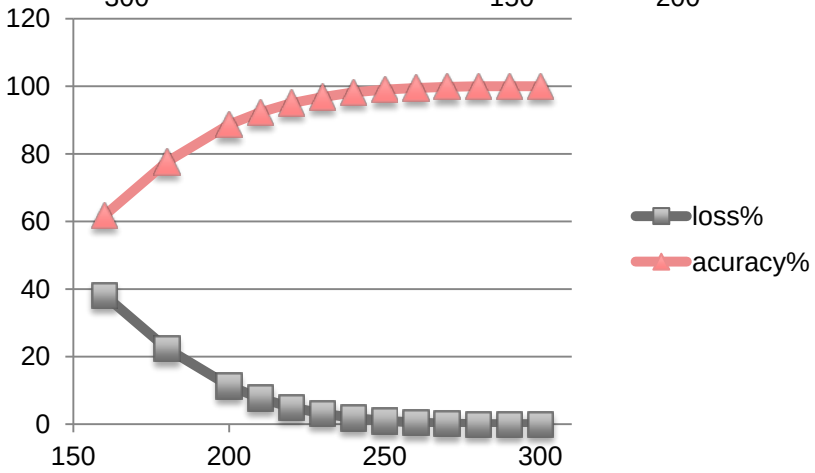
Experiment Results



Cutsheet EP



Continuous form inkjet



Desktop inkjet

What is the acceptable ink/toner limit?

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	CT inkjet	CS EP	desktop inkjet
220%	95.47	94.11	95
230%	97.21	96.33	96.8
240%	98.61	98.01	98.2
250%	99.17	98.93	99
260%	99.68	99.55	99.5
270%	99.89	99.84	99.83

Recommendation: No lower than 230% to minimize apparent color errors

On going experiments

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Relationship between ink limit and color quality

- How does gamut ratio $V_{inkLimit}/V_0$ relate to color quality? Where V_0 is the gamut volume of 400% ink coverage, and $V_{inkLimit}$ is the gamut volume of the ink coverage at the ink limit.
- Predicting that the gamut volume ratio is the key parameter for determining the ink limit with an acceptable color quality

What would we like ICC to help

- Get feedback on our study
- Other members share their knowledge and study
- Possible white paper on printer ink limit recommendation

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Questions?

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