An Investigation of Factors Influencing Color Tolerances

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Introduction

- Print buyers demand quality printing.
  - Quality printing means conformance to specifications
- Specifications are developed by standardization bodies.
  - Regional standards are developed by printing associations, e.g., IDEAlliance in the U.S.
  - International standards are developed by ISO TC130.

History of ISO TC130

- TC130 Graphic technology started in 1971.
  - TC130 was reactivated in 1989.
  - TC130 has 14 Working Groups.
  - WG3 is responsible for developing and revising specifications in printing standards.
  - A good example is the ISO 12647 series of printing standards.

History of ISO 12647-2

- Originally published in 1996.
  - $\Delta E_{ab}$ metric was used to define color tolerances of CMYK solids. Density of solids are specified as informative.

- Magnitudes of tolerance for CMYK solids were changed from unequal to equal.

- The most recent revision was in 2013.
  - $\Delta E_{ab}$ remained as the normative metric. $\Delta E_{00}$ was added as an informative metric.
Problem Statements

- There is a lack of understanding or documentation as to
  - How was the magnitude of $\Delta E_{ab}$ tolerance initially specified in 1996?
  - Why were these magnitudes revised in 2004?
  - How was the magnitude of $\Delta E_{00}$ tolerance specified in relation to $\Delta E_{ab}$ tolerance?

Research Questions

1. What factors influence the magnitude of color tolerance?
2. Is there tolerance equivalency between the old metric ($\Delta E_{ab}$) and the new metric ($\Delta E_{00}$)?

Note: The same $\Delta E_{00}$ tolerance may represent visual agreement for all colors. This means there is no point to determine the $\Delta E_{ab}$ and $\Delta E_{00}$ equivalency. But, this is outside the scope of the study.

Tolerance & %Pass

- Tolerance is the permissive color difference that determines whether a printed job passes or fails.
- The passing probability of a job, known as %Pass, is the percentage of jobs that conform to all normative requirements in a database (Chung & Feng, 2012).

\[
\text{%Pass} = \frac{A}{A + B} \times 100
\]

Boundary Data Approach

- Using the boundary data to determine the new tolerance metric ($\Delta E_{00}$) from the old metric ($\Delta E_{ab}$)
  - No unique solution -- Single $\Delta E_{ab}$ will map to a range of $\Delta E_{00}$ (Chung & Chen, 2011).

Real Database Approach

- Finding %Pass of two metrics using a database (Chung, Urbain & Sheng, 2014)

\[
\text{%Pass}_{\text{lower}} = \frac{A + B}{A + B + C + D} \times 100
\]

%Pass$_{\text{lower}}$ = \frac{A + C}{A + B + C + D} \times 100

- If the relation between %Pass and tolerance can be determined, the equivalent tolerance is when both tolerance metrics produce the same %Pass.

Methodology, Part 1

- To determine the relation between tolerance & %Pass,
  - Select Fogra PSO database (185 jobs for CMYK solids)
  - CIELAB values of the ISO 12647-2 aims
  - OK sheet for each job
Methodology, Part 1

- Compute $\Delta E_{ab}$ and $\Delta E_{00}$ for each job in the database.
- Compute %Pass according to ISO 12647-2 (2013) specified tolerances.

Results, Part 1

- $\Delta E_{ab}$ distribution of CMYK solids and %Pass at 5 $\Delta E_{ab}$ tolerance.
- $\Delta E_{00}$ distribution of CMYK solids and %Pass at 3.5 $\Delta E_{00}$ for CMY and 5 $\Delta E_{00}$ for K.

Methodology, Part 2

- To determine the tolerance equivalency between the old metric and the new metric,
  1. Determine %Pass by varying $\Delta E_{ab}$ and $\Delta E_{00}$ tolerances.
  2. For each metric, plot %Pass as a function of tolerance.

Results, Part 2

- The graphs of %Pass vs. tolerance show that
  - %Pass is proportional to tolerance magnitude.
  - $\Delta E_{ab}$ is a larger metric than $\Delta E_{ab}$.
  - There is a larger $\Delta E_{ab}/\Delta E_{00}$ ratio for Yellow solid than for Black solid.

Results, Part 2

- By using the ray-tracing techniques, we can find the equivalent $\Delta E_{00}$ that would yield the same %Pass as the specified $\Delta E_{ab}$ color by color.

Discussions

- %Pass for both metrics according to ISO 12647-2 are high.
Discussions

• Using the equal %Pass as the tolerancing criteria, it will yield unequal tolerances.

<table>
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<tr>
<th>Method</th>
<th>%Pass</th>
<th>%Tolerance</th>
<th>%Improvement</th>
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<tbody>
<tr>
<td>Local</td>
<td>99.5</td>
<td>97.8</td>
<td>95.7</td>
</tr>
<tr>
<td>ISO 12647-7</td>
<td>98.9</td>
<td>97.8</td>
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</tbody>
</table>

Conclusions

• The proposed method, using equal %Pass in a real database, provide us a solution to find the equivalent tolerances between \( \Delta E^{*ab} \) and \( \Delta E^{00} \).

• Regional printing associations and certification bodies should apply the methodology with larger databases, including non-conforming jobs, to assess how tolerances and %Pass perform in the industry.

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Thank you

Q&A