A Predictive Model for Text Quality Analysis: Case Study

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Background

- To explore an instrumented (objective) approach to predict text quality preferences (subjective).
- A challenging (complex) undertaking; many prior efforts & contributions by others.
- A case study *towards* a predictive model – possibilities and challenges?
Subjective Survey

• 10 samples, 3 printing technologies (imagesetter, electrophotography, inkjet); a range of print quality.

• Ten observers, each performed a complete combinatorial pair-wise comparison of all 10 samples (details reported in proceeding).

• Observers provided comments on why preferred one sample over another at end of survey.

• Data tallied, analyzed and reported on scale of 0 (least preferred) to 10 (most preferred).
Survey Results
What do the observers really see?
(As they make their preference decisions)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Score (0 to 10)</th>
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<tbody>
<tr>
<td>X1</td>
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</tr>
<tr>
<td>X2</td>
<td>7.6</td>
</tr>
<tr>
<td>F8</td>
<td>7.4</td>
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<tr>
<td>F1</td>
<td>6.2</td>
</tr>
<tr>
<td>F9</td>
<td>5.8</td>
</tr>
<tr>
<td>X6</td>
<td>5.7</td>
</tr>
<tr>
<td>B4</td>
<td>5.5</td>
</tr>
<tr>
<td>B3</td>
<td>1.7</td>
</tr>
<tr>
<td>B8</td>
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4 pt Times Roman
IS&T NIP23, Sep 28, 2007 Anchorage, Alaska
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Decreasing Preference

4 pt Times Roman
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9 pt Chinese Char.
Observer Comments
(Obtained 8 out of 10; abbreviated to fit into slide)

• Contrast is important; clarity of lines leaves good impression.
• Like dark and sharp text.
• Looked at sharpness of 4 pt fonts. Overall darkness & edge smoothness.
• Strokes should be sharp, distinct without voids.
• First looked at large letters & then judge if text is easy to read.
• B8 is too light; X6 and B3 seem “grainier” than others.
• Attributes in order: sharpness, contrast, density & stroke width.
• Decided based on darkness of print, clarity of fonts and whether thin lines showed clearly.
Comments Summary

• Clarity, sharpness, distinctness (goodness measures)
• Contrast, darkness, density (goodness measures)
• Discontinuities, voids, graininess (defect measures)

⇒ Objective stroke properties analysis?
Objective Stroke Quality Analysis

• Instrumented analysis (portable image analysis system – QEA PIAS-II), ISO13660 based line quality tools.


• Stroke properties: width, blurriness, raggedness, density and contrast.
Objective Analysis Results (1)

Empirically: Blurriness & Raggedness are correlated, so are Density & Contrast. \therefore simplify by using only Blurriness, contrast, and stroke width in subsequent analyses.
Objective Analysis Results (2)

Correlation with stroke width is somewhat unclear – perhaps an optimum at 400µm? (ref. R. Edinger’s study)
Objective Analysis Results (3)

Correlation with contrast (or density) exists but "noisy"
Correlation with blurriness (or raggedness) is quite strong.

R\(^2\) \sim 0.82\) with X9, \sim 0.95\) without
A Linear Regression Model

• Using a least-square method (excluding X9):

Score = -37.7B + 5.38C + 16.4W

Where: B = edge blurriness, mm
       C = stroke contrast
       W = stroke width, mm
Checking the “Reasonableness”

\[ y = 0.927x + 0.387 \]
\[ R^2 = 0.904 \]
Limitation of the Model

• Doesn’t account for **Text Defects!!**
• Text defects – examples:
  
  Poor formation, missing serifs, jitter, voids, distortion, unattractive character spacing, ...
Text Defect - Example

- Sample X9 is an outlier in the model – much lower subjective score than B3 & B8 despite:
  - Wider, lower blurriness and higher contrast than B3 & B8
  - Better MTF than B3 and B8
  - Character formation problem
  - High edge distortion & roughness
Summary

• Text Quality “goodness” attributes:
  – Clarity, sharpness and distinctness (measured in terms of blurriness or raggedness)
  – Contrast and density
  – Stroke width (perhaps an optimum exists)

• Empirical model allows reasonable prediction of subjective score

• Needs to account for effect of text “defects.”
Acknowledgment

• Thanks to all the colleagues in the INCITS W1.1 Line and Text Quality Ad Hoc Committee (working towards the ISO19751 Perceptual Image Quality Standard) for providing a stimulating environment for many valuable discussions and insights. The Ad Hoc Group Chairman is Dr. Edul Dalal of Xerox Corporation.