Relationship between Chinese Text (Kanji) Quality and Card Printing Technology

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Abstract

Reproduction of Chinese text is inherently more difficult than the reproduction of Latin characters due to the complexity of Chinese characters. Contrast, resolution, and color registration are critical, and failure to maintain these factors rapidly leads to degradation of Chinese text quality.

Analysis of a representative Chinese character illustrates how these factors vary with imaging systems typically used to produce plastic cards. In fact, a direct correlation exists between resolution and the ability to accurately reproduce small font sizes, with 300 dpi sufficient for 8 pt text, 600 dpi required for 4 pt, and 1200 dpi for 3 pt. This correlation represents minimum required resolution. If other factors, such as low contrast or color registration, degrade the image, even higher resolution is required.

Introduction

Plastic cards in Asian countries, including ID and credit cards, frequently contain Chinese text, with character sizes between two and ten points. With 29 strokes or more,[1] these characters have far greater complexity than Latin characters. Card applications generally use thermal resin transfer or retransfer, inkjet, electrophotographic, and direct laser engraving technologies to reproduce text. Thermal resin transfer is typically used for black text in combination with thermal dye sublimation for color printing, although high-resolution thermal printing systems may use thermal resin transfer for all four colors. Thermal resin transfer differs from thermal resin retransfer, in that transfer uses direct-to-card printing, while retransfer involves printing to an intermediate transfer ribbon followed by transfer of the resulting image to the plastic card.

These printing technologies for plastic cards are chosen because they typically give a very sharp edge that produces high-quality text. Retransfer processes are particularly important because they are compatible with more substrates and allow edge-to-edge printing on technology cards that may not be perfectly flat.

Previous predictive models have examined the effect of clarity, contrast, and image defects, including discontinuities, voids, and graininess, on text quality.[2] Other models relate the modulation transfer function (MTF) of closely spaced lines to text image quality.[3] In a related study of image scanners, sharpness, contrast, darkness, thickness, and non-homogeneity were the key attributes for text quality.[4]

Since Chinese text includes many fine features, print resolution and addressability directly affects the ability of a printing system to reproduce the text. For multicolor printing system, color registration also comes into play, since misregistered colors will introduce color halos and other image artifacts. Finally, the ability of a printing system to reproduce negative white on black text may differ significantly from the ability of the system to reproduce standard positive text.

Methodology

The Microsoft SimSun (Apple STSong) font[5] is a standard font for Chinese characters used in this study. The test target also included a slanted-edge square to measure special frequency response and line patterns with line widths of 0.020, 0.041, and 0.083 mm and spacings between 0.135 and 0.334 mm intended to simulate reproduction of Chinese characters.

The text analysis tool included with the QEA PIAS-II measured relevant text features, with thresholds selected to reflect visually observed text boundaries. The same measurement applied to the Chinese text target file at a resolution of 9600 dpi defined the theoretical area.

Subjective evaluations were carried out according to the following five ratings: 1) No apparent defects. 2) Some defects are present that do not generally affect interpretation of the text. 3) Significant defects are present that do affect interpretation of the text. 4) Major defects are present that significantly affect interpretation of the text. 5) The text is completely illegible. Text in categories 1 and 2 was used to define the minimum legible font size.

Results and Discussion

This study makes specific recommendations for the printing technology and resulting image quality required to accurately reproduce Chinese text. In doing so, we quantitatively compare different print technologies, including inkjet, thermal resin transfer and retransfer, electrophotography, and laser engraving. These printing technologies have high edge contrast and are well suited to the reproduction of text. Of these technologies, laser engraving is unique because it writes directly to the card at very high resolution, eliminating any transfer or colorant deposition steps that reduce effective resolution. In this case, resolution and dot positioning accuracy are the primary factors which determine text quality.

MTF type measurements, including measurements of the spatial frequency response measured using the ISO 12233 slanted-edge technique, showed little correlation to observed text quality for the Chinese text quality test target, Figure 1.

Figure 1. Test Targets for evaluating Chinese text quality, including black text on white (A), white text on black (B).

Similarly, line patterns with line widths between 20 μm and 85 μm with spacings between 120 and 340 μm proved unable to predict Chinese text quality. In this evaluation, printing systems that were able to print small font size Chinese characters were also able to print closely spaced lines. The converse proved untrue in that some printing systems that were able to resolve closely spaced lines were unable to reproduce the complexities of Chinese Characters. Instead, direct analysis of Chinese text proved particularly valuable. To ensure that uniform evaluation of all systems, one 19-stroke character was selected for further analysis, Figure 2. This character includes horizontal and vertical lines, angled lines, and lines of varying thickness.

Figure 2. Representative Chinese character.

Contrast

Printing technologies with low edge contrast, such as thermal dye sublimation, are less able to reproduce small font sizes, Figure 3.
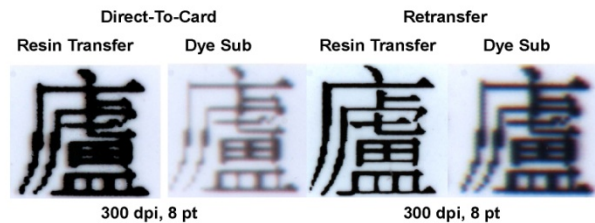

Figure 3. Photomicrographs comparing 8 pt Chinese text for black on white and white on black text.

Dye sublimation systems are ideally suited for the reproduction of continuous tone photographs but need to be combined with a high contrast printing technology to produce high quality text. For thermal printers, this requirement typically means that thermal resin transfer, rather than dye sub, is used to print text.

Reproduction of reverse text (white text on black) is more difficult than normal text (black text on white) since many printing systems show dot gain, which tends to fill in small areas of white text reducing overall quality. Fill-in proved less problematic for high-quality inkjet and laser engraving on plastic, since these technologies had lower dot gain with reverse text than other printing systems in this study, Figure 4.
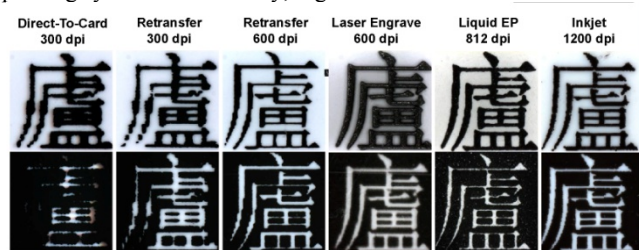

Figure 4. Comparisons of 8 pt Chinese text for black on white and white on black text.

Resolution

Higher resolution printing systems reproduce proportionately smaller text sizes with equivalent fidelity, Figure 5.
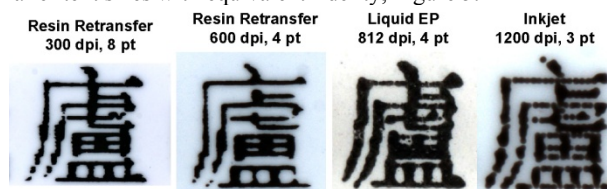

Figure 5. Reproduction of small character sizes with printing technologies of varying resolution.

At 1200 dpi, inkjet has the highest resolution of the printing technologies in this study. Inkjet is able to reproduce 3 pt Chinese text. On the other hand, 300 dpi systems are limited to 8 pt text.

To a first approximation, the ability to reproduce small text sizes depends inversely on the resolution, since accurate reproduction of give character depends on the number of pixels in a given area, Figure 6.
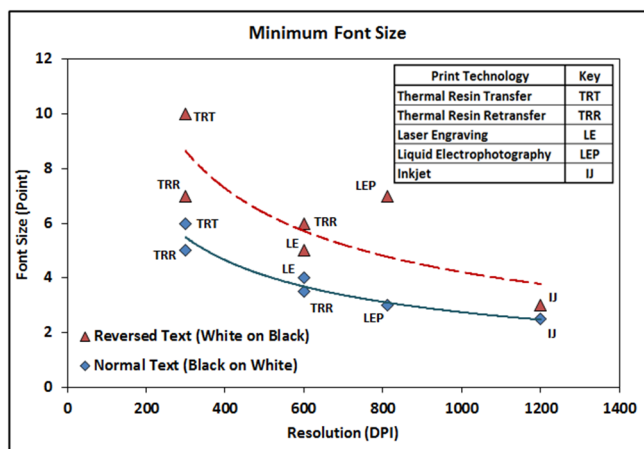
Figure 6. Minimum legible font size for thermal resin transfer and retransfer (300 dpi), thermal resin retransfer and laser engraving (600 dpi), liquid electrophotographic (812 dpi) and inkjet (1200 dpi).

Some dot gain improves the quality of black text on white. Comparisons of the actual character area to the theoretical area show this effect as well as the degradation that results when character area continues to increase, Table 1. For white text on black, the effect is reversed, with dot gain serving only to degrade text quality.

Table 1. Ratio of Area$_{Measured}$ to Area$_{Theory}$ for Chinese character 盧.

	Area$_{Measured}$/Area$_{Theory}$			
	No Defects	Some Defects	Significant Defects	Major Defects
Black on White	1.35 ± 0.19	1.70 ± 0.23	1.92 ± 0.44	2.38 ± 0.19
White on Black	0.86 ± 0.13	0.72 ± 0.09	0.52 ± 0.04	0.31 ± 0.04

Black on white characters maintain image quality as long as the increase in area is less than about 70%, while white on black characters can maintain image quality with a 30% loss of area. Of course, tighter tolerances will further improve image quality, and less complex characters can be reproduced more easily.

Color

Composite color produces black text that is inferior to single color systems. In this case, the difficulty with simultaneously maintaining resolution and color registration results in lower text quality. For this reason, small font sizes require single color printing. In some cases the same file printed through different software applications produces markedly different results, with text quality dependent on the process used to convert vector text into raster graphics, Figure 7.
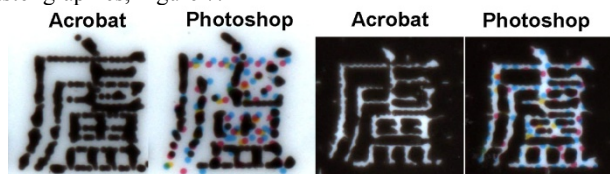

Figure 7. Comparison between printing with Adobe Acrobat and Adobe Photoshop for 3 pt inkjet Chinese characters.

To ensure consistency in this study, Adobe Acrobat was used to print all samples, except where specialized software was required, such as for the laser engraver.

Composite text also requires the printing system to maintain registration between four process colors, introducing another potential difficulty, Figure 8.
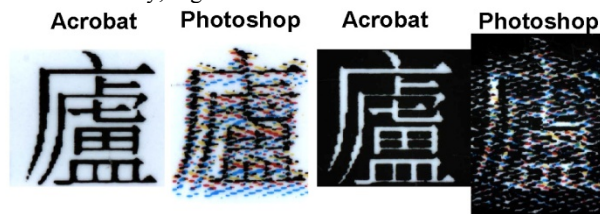

Figure 8. Comparison between printing with Adobe Acrobat and Adobe Photoshop for 8 pt 600 dpi thermal retransfer Chinese characters.

Conclusion

While it is impossible to evaluate all possible printing systems in a single study, subjective image quality assessments confirm that quantitative measurements correlate well with observed image quality. These evaluations show that as Chinese text size is reduced, higher resolution is required to maintain image quality. They also confirm the need for high contrast and either single color printing or carefully registered composite printing.

As a general rule, low resolution 300 dpi card printing systems required font sizes between eight and ten points, while high resolution 1200 dpi printers can accurately reproduce two to three point text. These results confirm that for reproducing Chinese text, when it comes to resolution more is better. Dot placement accuracy and color registration are also critical.

The easiest way to maintain contrast and color registration is to carefully select the printing technology for the Chinese character text. Specifically, high contrast single color systems produce the highest quality text with the least amount of difficulty.

References

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