Color Imaging Using Variable Dot Thermal Wax Transfer

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Abstract

Traditionally, thermal transfer printing has been a binary process. This means that for a given location on a page, either a dot of colorant is deposited or is not. Various dithering techniques are used in order to create intermediate tone levels. In comparison, variable dot thermal transfer utilizes colorant dots with a continuum of possible sizes. Consequently, dithering techniques used for traditional fixed dot size thermal transfer printing are not needed. This results in greatly improved image quality. The resolution of variable dot thermal transfer has been shown to be considerably better than ink jet or traditional thermal transfer and comparable to dye diffusion. Furthermore, variable dot thermal transfer has speed, cost and permanence advantages with respect to other color printing technologies.

Introduction

Thermal wax transfer printing typically consists of a donor, a receiver and a printhead. In this case the printhead has a fixed energy level and results in an approximately fixed dot size and constant density. This system is demonstrated in Figure 1. In comparison, variable dot thermal transfer utilizes a high definition ribbon, a special micropore receiver and a print head capable of energy modulation. This results in a dot with a roughly fixed density but varying dot area and is shown in Figure 2.

This process offers a number of potential advantages:

• Variable dot thermal transfer can achieve higher spatial resolutions. Intermediate tone levels will relax the spatial resolution color resolution trade-off encountered in digital halftoning for a device. The image quality of variable dot exceeds ink jet and thermal wax and approaches dye diffusion.

• High image quality at a cost below that of dye diffusion. Both the donor and the receiver are less expensive than the corresponding dye sublimation con- sumables. Based on initial estimates, the cost of variable dot thermal transfer should be about half the cost of dye diffusion printing.

• Thermal uses pigments that are more similar to printing inks than the dye diffusion dyes. This results in a less metameric match between the processes. Subsequently, the color matches will not deviate as much as a result of a change in illumination.

• The pigment based colorants in thermal wax transfer are more light, water and rub fast than either ink jet or dye diffusion. The dyes used in ink jet and dye diffusion printer fade more quickly and less durable than the pigments used in the thermal wax ribbons.

• The dye diffusion process requires considerably higher energy levels than the thermal wax transfer process. This is because less energy is required to melt wax than to diffuse dye. Consequently, print times will be faster, the operational voltage will be lower and there will be less wear on the printhead for variable dot than for dye diffusion.

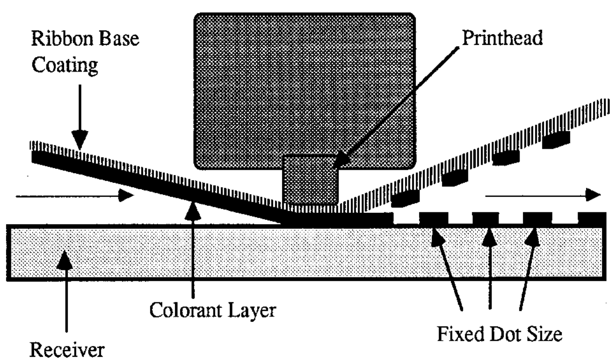

Figure 1. Traditional fixed dot thermal wax transfer

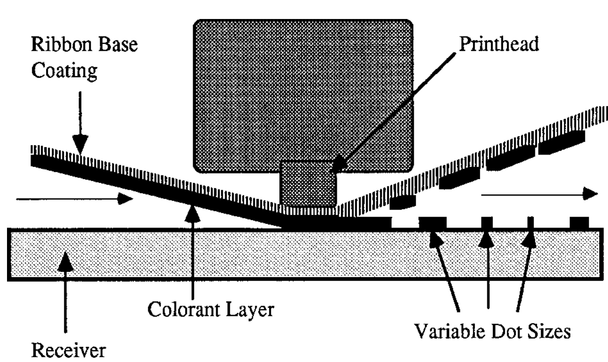

Figure 2. Variable dot thermal wax transfer

Variable Dot Imaging System

The variable dot thermal transfer process utilizes a special high definition donor. This donor is similar to other thermal wax ribbons. The is a back coating, a base coating , and a colorant layer. The primary difference between normal thermal transfer ribbon and the high definition ribbon is the thickness. The high definition ribbon is considerably thinner than the normal donor. The thinner donor should contribute to improved dot resolution.[1]

Thus far the best receiver has been found to be a synthetic micropore substrate. This receiver consists of a thick base coated by a thin layer of extremely smooth and porous synthetic material. Previous research has demonstrated that smoother receivers yield improved image quality for thermal transfer printing.[2,3] For variable dot thermal transfer printing, the smoothness will still be important but it is uncertain what role the receiver porosity has on image quality.

The printer utilized for this research was a hybrid 300 dpi dye diffusion printer. This allowed individual print elements to be pulsed for variable amounts of time. The printer was a hybrid in that the paper transport, peel angle and platen were designed for traditional thermal wax transfer. Additional work is necessary in order to determine how these parameters might be customized for variable dot printing.

Printer Configuration

The printer controller code allowed control over the Time On or T-on, Time Off or T-off and the number of repetitions for each strobe groups. The T-on specified the number of microseconds a given print element was pulsed. The T-off determined how many microseconds until the print element would be pulsed again. The pulsing of the print element results in an increase in the temperature of that element and this heat is conducted to the ribbon. Further details on this intricate process presented in the literature.[4,5]

Initial effort focused on deriving 3 bit strobe tables. A designed experiment was performed to determine the effect of T-on, T-off and repetitions on the process. Then the minimum and maximum energy levels were determined and this interval was subdivided to get eight tone levels. The strobe tables were then adjusted to correct for differences in colorant sensitivities.

The three bit strobe tables were then extended to four bits. This resulted in 16 levels of dot area modulation. The three and four bit strobe tables are compared in Figure 3. This figure shows a normalized tone level value along the x axis and a relative colorant amount on the y axis. The normalized tone level is the input digital count divided by the number of tone levels multiplied by 100. The relative colorant amount is the CIELAB ΔE* from paper for the given patch divided by the maximum CIELAB ΔE* from paper. The two curves show the progression for two cyan ramps printed with the 3 and 4 bit tables.

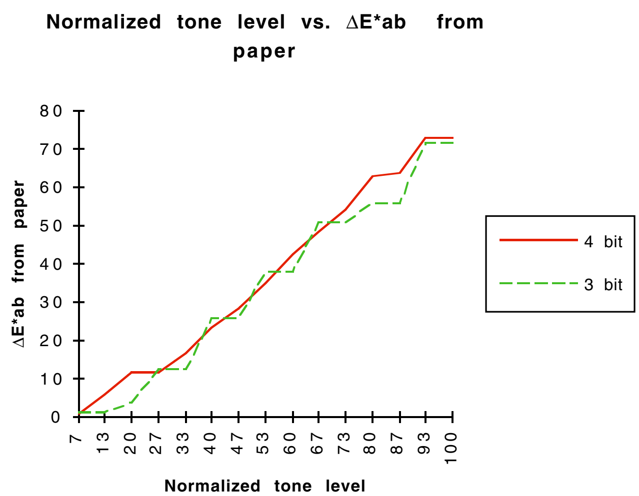

Figure 3. Comparison of 3 and 4 bit strobe tables

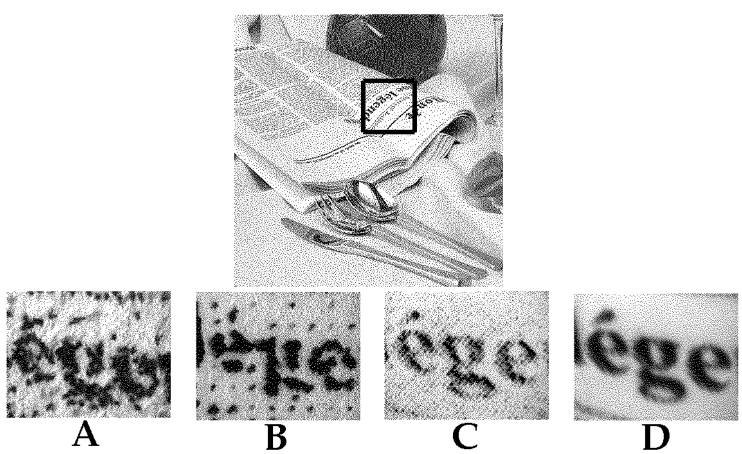

Figure 4. Portion of original 300 dpi image printed on A) ink jet B) traditional thermal transfer C) variable dot thermal transfer and D) dye diffusion printers.

Results

Variable dot thermal wax printing results in considerable improvement in the spatial resolution of the printed image. The level of detail shown in the variable dot prints is much better than ink jet or thermal wax and approaches dye diffusion. This is illustrated in Figure 4 where a test image is shown approximately to scale at the top of the figure. Below this original image are four close-ups of a portion of the original image printed with four different devices. The images shown in A and B are ink jet and thermal wax transfer prints of the original. The variable dot thermal wax and dye diffusion prints are shown in images C and D. The improvement in detail is evident.

By modulating the dot area, the resolution of the variable dot process is greatly enhanced. However, the next objective is to maximize the number of significant dot areas. This printer was configured with 8 and 16 significant tone levels. Increasing the number of levels was limited by variation in the dot modulation. This non-uniformity in dot areas for a solid region is one of the major limitations on image quality. Furthermore, overprints tend to exhibit a certain level of non-uniformity.

Conclusions

Variable dot thermal wax printing is a viable technology with a number of potential advantages. The major advantages are the improved image quality for a cost lower than dye diffusion.[6] Initial work has been conducted into the donor and receiver for this system. In addition, the entire system has been investigated using the test bed described in this article. However, the complex process still has some unresolved issues. The process is distinct from either traditional thermal wax transfer or dye diffusion printing. The platen pressure, peel angle, and print speeds have yet to be completely optimized for variable dot thermal transfer.

References

1. John Hae-Tak Choi, "Effect of mechanical factors on and peel force in a peel-apart imaging film", *J. Img. Tech.* **15**, 190-195 (1989).
2. E. Anczurowski and D. J. Saunders, "Materials for thermal transfer printing", *J. Img. Tech.* **13**, 97-102 (1987).
3. M. Kato, T. Minato, T. Nagura, and K. Yasuda, "The role of receiving sheet substrates in thermal dye transfer imaging", *J. Img. Tech.* **16**, 242-244 (1990).
4. R. A. Hann and N. C. Beck, "Dye diffusion thermal transfer (D2T2) color printing", *J. Img. Tech.* **16**, 238-241 (1990).
5. D. J. Saunders, "Heat conduction in thermal transfer printing", *Can. J. Chem.* **63**, 184-188 (1985).
6. Paul Swift, "IIMAK provides variable-dot thermal transfer performance details", *Color Business Report* **4**, 9-12 (1994).