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Comparative Analysis of Color Simulation between Offset Printing and Inkjet Printing

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ABSTRACT

This paper presents an analysis of the color output capability and accuracy of an inkjet printer, specifically the Epson L1800, used for simulating offset printing. The colorimetric values of the printer's cyan, magenta, yellow, and black primaries were found to be different from those used in offset printing, and attempts to adjust the maximal output ink level and tone curve were not able to fully eliminate the differences. As a result, the Epson printer's color gamut did not completely meet the requirements of offset printing, particularly in terms of high-chroma colors. However, the printer calibration process improved the printer's capacity and overall color output accuracy within the offset color gamut, with significant color differences only occurring for colors outside the printer's gamut. This study provides insights into the challenges and limitations of using an inkjet printer for simulating offset printing and highlights the importance of printer calibration for achieving accurate color reproduction in this context. Further research may focus on developing more advanced calibration methods or exploring alternative printer technologies to improve the accuracy of offset printing simulation using inkjet printers.

Keywords: Inkjet Printer, Offset Printing, Simulation, Proof Printer, Color Management

I. INTRODUCTION

Simulating offset printing using inkjet printers has gained significant attention in recent years due to its potential for cost-effective and flexible printing. This approach involves emulating the color reproduction of offset printing, which is a widely used printing process, using inkjet printers. However, simulating offset printing using an inkjet printer presents challenges in achieving color accuracy, resolution and sharpness, ink spread and paper characteristics, accounting for environmental conditions, and accommodating real-world printing applications. These challenges arise from differences in color models, ink formulations, print resolution, ink application methods, and environmental factors between offset printing and inkjet printing [1-4]. To overcome these problems, many studies have approached so far. The results archived by T. Lee et al. [5] and J. Smith et al. [6] have made notable progress in developing simulation methods for offset printing using inkjet printers, focusing on resolution, image sharpness, color accuracy, and color matching models such as RGB-CMYK, Lab, and ICC. However, the current problems that need to be addressed include improving accuracy and stability under different printing conditions, optimizing and evaluating the applicability of the methods in real-world applications. In this paper the color output capability and the method for simulating offset colors with an inkjet printer Epson L1800 were analyzed.

II. METHODS AND MATERIAL

A. Experiment

In our experiment, Epson L1800 inkjet printing (Fig.1) and the ISO12647-2 standard offset output (simply called the Epson and the ISOOffset here after) were chosen as the two sorts of printings. The Epson printer was setup at the default working (Epson photo glossy paper). The ISO Offset printing was archived by using a Roland 700 evolution offset press on Couche 150 g/m2 paper (paper type 1).

Figure 1: The CMYK test target

The test file was the ECI2002 random characterization target for device profiling and for quantitative analysis (Fig.2).

The ECI2002 chart was printed by the Epson machine at the color mode of CMYK proof to the ISO offset target with its rending intent was set to absolute colorimetric. This process were driven by a third RIP software.

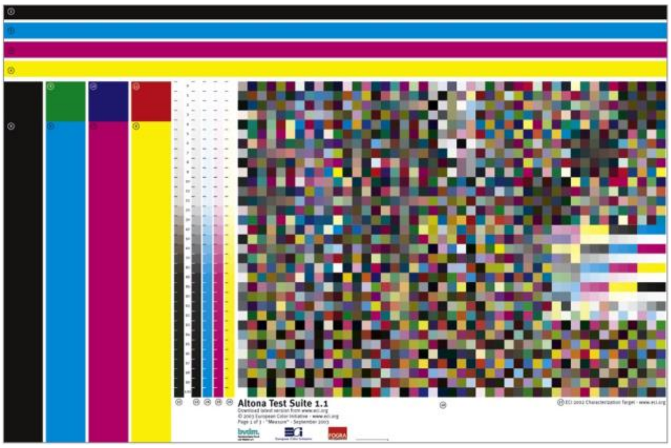


Figure 2: The CMYK test target

B. Density and CIE Lab value measurement

The color values were quantified numerically by the CIELAB color model. The CIE Lab values were calculated by an X_Rite SpectroDensitometer 504, Inc.Grandville, MI. The colour characteristics were calculated in the CIELAB color model by following equations [7].

Hue $H^* = artg(\frac{b^*}{a^*})$

Chroma $C^* = \sqrt{a^{*2} + b^{*2}}$

Color difference $\Delta E_{ab} = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$

III.RESULTS AND DISCUSSION

A. Comparison of color properties between the inkjet and offset printing

In order for a digital machine to be comparable to an offset device, it must fulfill two requirements. Firstly, it should be capable of reproducing all the colors of the offset. Secondly, it should have the same CMYK device color values as the offset for all the colors. Therefore, we will assess these aspects.

Color gamut. Color gamut is typically defined by a volume in the CIELAB color space, which represents all the colors that a device can output. The outer boundaries of the gamut can be determined using the device's profile. Fig. 3 shows the gamut comparison between the Epson and the ISO offset based on their profiles

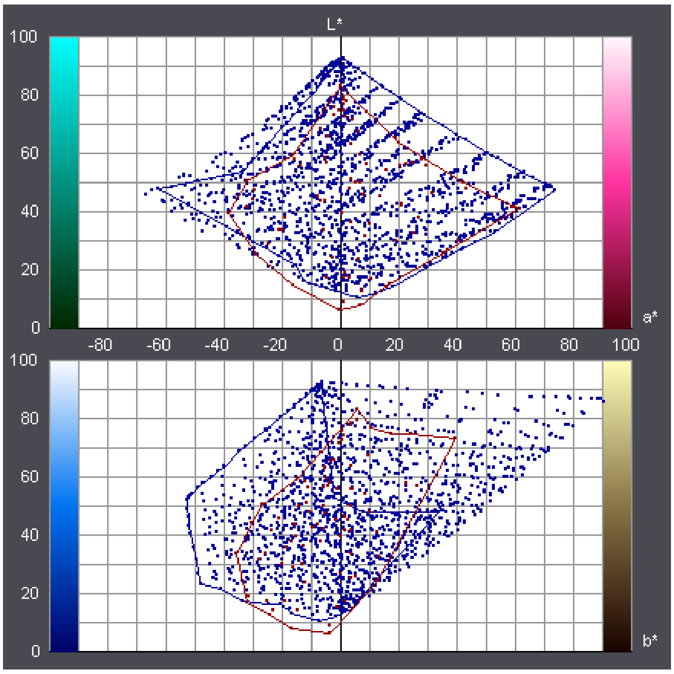


Figure 3: Gamut comparison between Epson (default) and ISOOffset

Bule: ISOOffset, Red: Epson

The findings from Fig.2 (a) indicate that the Epson inkjet printer is capable of reproducing fewer chromatic colors compared to the ISO offset printer. This can be attributed to the differences in the color properties of their primaries, as shown in Table 1. The disparities in the primaries are quite significant, with colorimetric values showing a color difference (ΔE) of greater than 10. These differences primarily stem from variations in hue angles and chroma values. The results suggest that the Epson printer may have limitations in accurately simulating high chroma colors of the ISO offset.

TABLE I

THE CIE-LAB COLORIMETRIC VALUES OF PRIMARIES

Color	Device	L	a	b	ΔEab
Cyan	Epson	58.65	-27.88	-35.36	18.71
	Offset	56.12	-34.90	-52.52	
Magenta	Epson	49.95	62.30	-5.71	13.94
	Offset	47.46	75.91	-7.40	
Yellow	Epson	83.92	-1.54	82.22	11.59
	Offset	88.94	-4.04	92.37	

The tone curve and the gray balance. At a definite state, the CMYK dot area values are usually not equal to output dot area values, and there is a relationship between them, called as tone curve. The tone value increase (TVI) of offset printers normally is higher than inkjet printer.

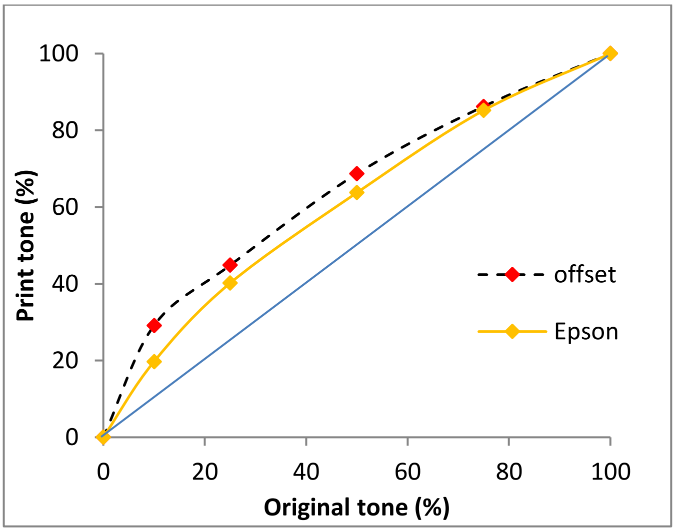


Figure 4: Tone curve (yellow) of Epson and ISOOffset

In offset printing, a predefined set of CMYK data corresponds to an output color, forming the standard, while a series of CMYK values corresponding to gray steps with different luminance are referred to as gray balance. It is important to note that each color system has its own unique gray balance. In our experiment, it was observed that the gray balance of the Epson printer differed from that of the ISO offset printer, resulting in a color image that was originally calibrated for ISO offset no longer having the correct gray balance (as shown in Table 2)

TABLE III

THE CIE-AB COLORIMETRIC VALUES OF GRAY BALANCE

Patch CMY	Offset		Epson		Δab
	a	b	a	b	
3, 2, 2	-0.19	1.07	0.14	-2.26	3.34
10, 8, 8	1.16	-3.73	1.68	-5.46	1.81
25, 19, 19	0.82	-2.89	-0.83	5.58	8.63
50, 40, 40	0.46	-2.02	-0.87	-2.30	1.36
75, 66, 66	-0.02	-0.84	-4.92	5.94	8.37
90, 85, 85	-0.24	0.07	-4.73	5.01	6.68
100,100,100	0	0	-0.12	4.07	4.08

B. Calibration of the inkjet printer

In our experimentation, we attempted to increase the chroma of the primary outputs in order to match the ISO offset standard. The ink limitation was investigated, and the results are reported in Fig.5. As evident from Fig.5, when the ink amount increases, the magnitude of the C* value moves towards the right for all the inks. However, it reaches its maximum saturation at a specific ink limit, after which the hue slice becomes less saturated as it darkens. The ink limits where the inks achieve the highest chroma are found to be 90% for cyan, 90% for magenta, and 120% for yellow, with corresponding ink densities of Dc = 1.21, Dm = 1.11, and Dy = 0.97. The colorimetric values of the adjusted colors are reported in Table 3.

TABLE IIIII

THE CIE-LAB COLORIMETRIC VALUES OF ADJUSTED PRIMARIES

Color	Device	L	a	b	ΔEab
Cyan	Epson	52.31	-31.02	-40.74	12.97
	Offset	56.12	-34.90	-52.52	
Magenta	Epson	47.12	66.82	-5.90	9.22
	Offset	47.46	75.91	-7.40	
Yellow	Epson	82.51	-4.66	83.91	10.64
	Offset	88.94	-4.04	92.37	

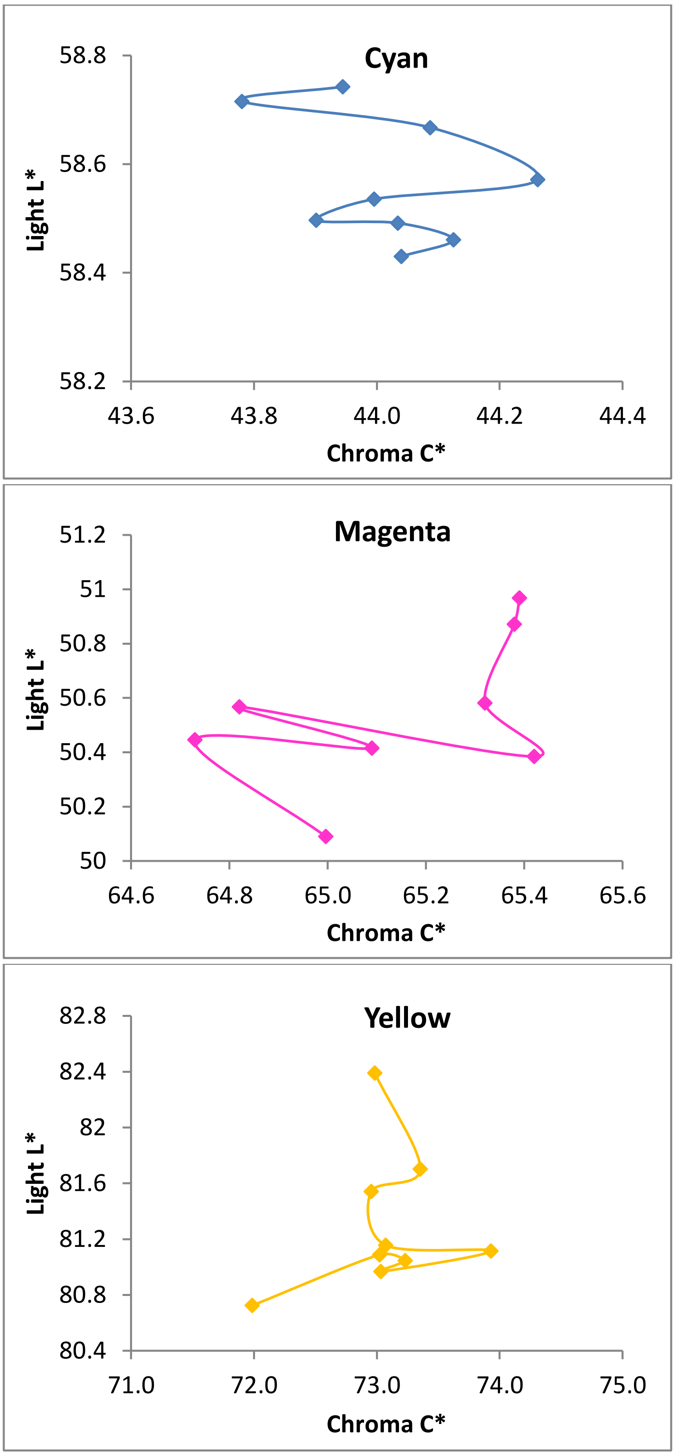
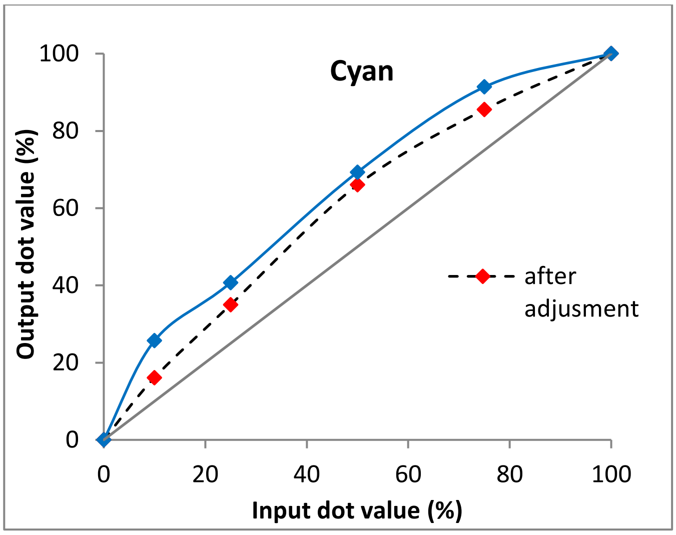
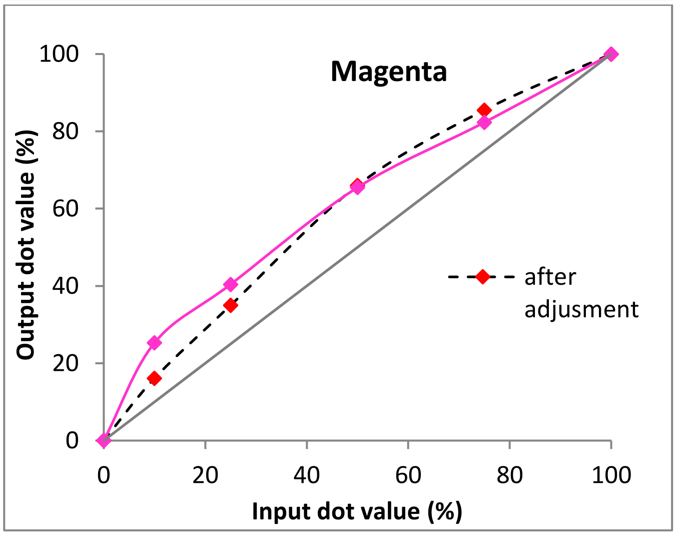


Figure 5: L*C* gamut plots of cyan, magenta and yellow hue

The hue and chroma of the Epson's adjusted primaries were observed to be closer to that of the ISO offset, but there was a noticeable drop in lightness and a deviation from the ISO offset's values. As a result, the tone curve needed to be modified. The tone curves of the four inks (cyan, magenta, yellow, and black) were adjusted individually in order to achieve a gray balance that matched that of the ISO offset. Fig.6 displays the dot tone curves before and after adjustment for each ink color (C, M, Y, K).

With the new curves, the gray balance was really very close to the ISO offset's. But it was noticed that the other colors were still much differ from the ISO offset.





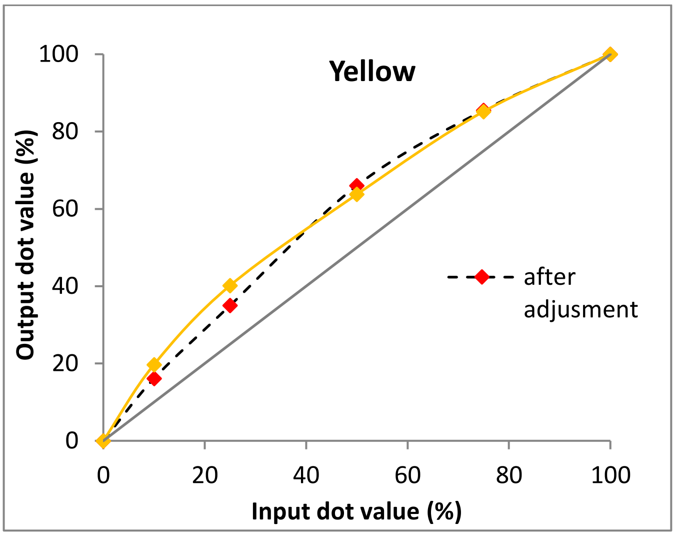


Figure 6: L*C* gamut plots of cyan, magenta and yellow hue

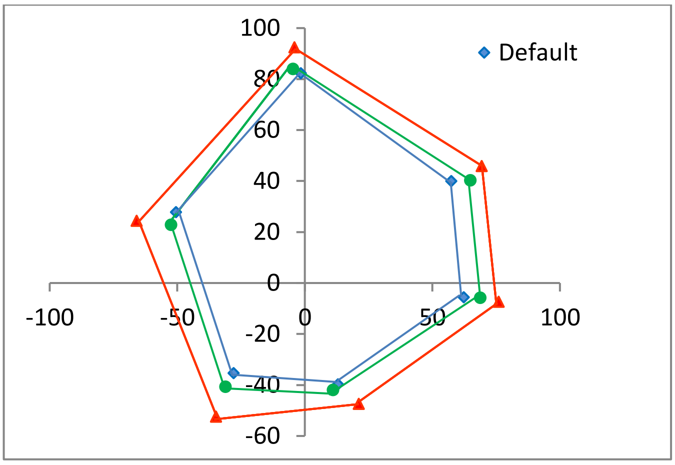


Figure 6: L*C* gamut plots of cyan, magenta and yellow hue

The primary colors and overprints of the printed image were compared to the ISO offset standard using CIE L*a*b* values, both at default and adjusted printer setups (as shown in Table 4). The results indicated that the inkjet printer exhibited improvement after calibration. However, the color difference between the two printing systems was still significant, with ΔEab values exceeding 5 for all solid colors. This suggests that simply adjusting the amount of inkjet printer's primaries may not be sufficient due to differences between the primaries of the two systems. Thus, the inkjet printer, such as the Epson L1800, may have limitations in accurately simulating ISO offset color output. Nevertheless, by employing color management techniques, such as color conversion, the inkjet printer was able to accurately simulate colors within the offset printer's gamut.

IV. CONCLUSION

In this paper, we conducted a simulating experiment using the ISO standard offset and Epson L1800 inkjet printing machine. The experiment results revealed that the digital machine exhibited some limitations in its color gamut, leading to larger color differences for high chromatic colors that were located on or near the gamut boundaries of offset printing. Adjusting the primary output level or tone curve of the digital machine did not result in successful matching of the offset's gamut. However, by calibrating and incorporating color management techniques, colors within the digital print gamut could be more accurately reproduced to match the offset colors. The method presented in this study could potentially be applied for analyzing similar systems in other contexts.

V. REFERENCES

[1]. Robert Chung, A Survey of digital and offset print quality issues, RIT Scholar Works, 2007
[2]. Stefan Livens, Marc Mahy and Dirk Vansteenkiste, How to ensure consistent colour quality in inkjet proofing, Proceedings of SPIE - The International Society for Optical Engineering, · December 2001
[3]. Xu Yanfanga, Jiang Guipingb, Wang Lilic, Liu Haoxue, Study on Color Simulating between Offset Printing and Digital Printing, Advanced Materials Research, 2011, 174
[4]. Proofing for Offset Printing Using an Inkjet Photo Printer and Photoshop Program, The Journal of the Korea Contents Association 2015, 15(1)
[5]. T. Lee and K. Chen , Inkjet Printing Simulation for Offset Print Quality, 2017
[6]. J. Smith and A. Johnson, Simulation of Offset Printing Effects in Inkjet Printing Using Mathematical Models, 2018.
[7]. Delta E: The Color Difference. Colorwiki.com. Retrieved 2009-04-16

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