The Differentiation of Color Laser Printers

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A survey of color laser printers from different manufacturers (Canon, Epson, Fuji Xerox, Ricoh, Minolta, Hewlett-Packard, and Tektronix) resulted in the observation of dotted motifs of different patterns on the printouts from Canon, Epson, Fuji Xerox, and Ricoh color laser printers. Studies thus far found that the dotted motifs were different on the same model of Canon printers that each bore a different serial number. The data suggests that these distinctive dotted patterns are related to the serial numbers of the machines and could be used for the identification of a particular color laser printer. A feasibility study on the use of Raman spectroscopy for the differentiation of toners of different manufacturers of color laser printers was found to be unhelpful in discriminating printers.

Introduction

Color laser printers are now among the most common office machines following a reduction in price in recent years. A computer system comprising a scanner and a color laser printer can generate and reproduce high-quality color images. The emergence of high-quality reproduction by laser technology has resulted in a more extensive usage of color laser printers, not only for legitimate purposes, but also for illegal activities such as the production of counterfeit banknotes and the forging of travel documents by the alteration of personal particulars and/or the substitution of the bearer's portrait.

A previous study (Arbouine and Day, 1994) revealed that a black-and-white laser printer might induce drum-fault markings onto its printouts. The marks on the printouts could be used to link the printouts to an individual laser printer. However, the study of color laser printers in document examination is less documented. Recent publications (Li and Leung, 1998 and Tweedy, 2001) have reported the presence of unique repeated dotted patterns on the printouts produced by some brands of color photocopiers that could be utilized for the identification of an individual color photocopier of a particular brand, model, and serial number. As color laser printers adopt a similar printing mechanism as those in color photocopiers, it is envisaged that dotted patterns could also be found on the printouts generated from the color laser printers.

This article reports the observation of dotted patterns on printouts made by some brands of color laser printers and discusses the possibility of using these patterns for the identification of a particular printer. In addition, a feasibility study on the use of Raman spectroscopy for the differentiation of toners of different manufacturers of laser printers has also been conducted. The aim is to determine whether toner particles from color laser printers of different brands will display different Raman spectroscopic properties. Such differences would help distinguish different brands of color laser printers.

Methods and Materials

Sample printouts were obtained from 21 color laser printers listed in Table 1. Microscopic examination of the color printouts using a Nikon Optiphot Microscope revealed the presence of repeated patterns of yellow dots on the printouts from Canon, Epson, Fuji Xerox, and Ricoh AP305 C2000 laser printers; however, these dots were too pale to be clearly visible under the microscope. It was found that by using the Video Spectral Comparator (VSC2000/HR), manufactured by Foster and Freeman Ltd. U.K., the dotted patterns could clearly be seen on the entire printout by illuminating the printouts with infrared light with bandpass filter at 431nm. Figures 1 to 6 illustrate the patterns of Canon CLBP400, Canon CLBP360PS, Epson AcuLaser C8500, Epson AcuLaser C2000, Fuji Xerox Docuprint C831, and

Brand	Model Number	Dotted Pattern
Canon	CLBP 400	Present
	CLBP 360 PS	Present
Epson	AcuLaser C8500	Present
	AcuLaser C2000	Present
FujiXerox	DocuPrint C831	Present
	Workcentre Pro412	Present
Ricoh	AP 305	Present
	AP 204	Absent
Hewlett Packard	Colour LaserJet 4500DN	Absent
	Colour LaserJet 4550	Absent
Tektronix	Phaser 8200 Black	Absent
	Phaser 7700 Black	Absent
	Phaser 7300 Black	Absent
	Phaser 6200 Black	Absent
	Phaser 1235 Black	Absent
	Phaser 850 Black	Absent
	Phaser 780 Black	Absent
	Phaser 750 Black	Absent
	Phaser 740 Black	Absent
Minolta	Magicolour 2 Desklaser	Absent
	Magicolour 6100	Absent

Table 1. Results of the examination of the presence of dotted pattern in different brands and models of color laser printers.

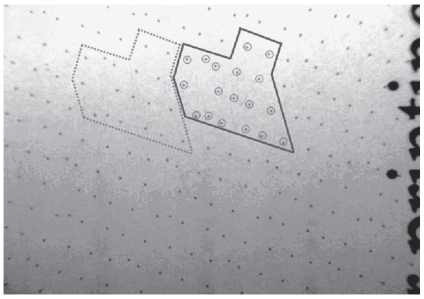

Figure 1. Arrangement of repeated dotted motifs present on a printout from Canon CLBP400 color laser printer.

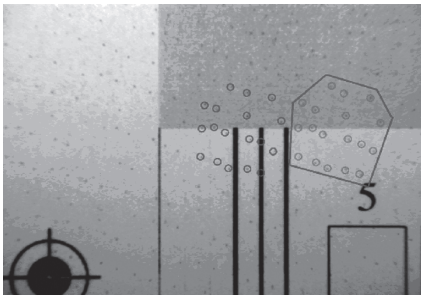

Figure 2. Arrangement of repeated dotted motifs present on a printout from Canon CLBP360PS color laser printer.

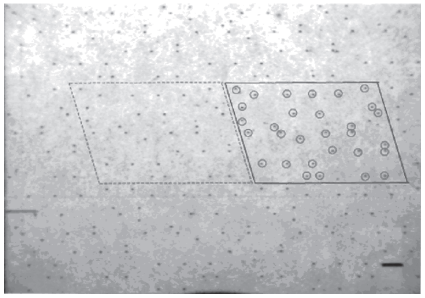

Figure 3. Arrangement of repeated dotted motifs present on a printout from Epson AcuLaser C2000 Color laser printer.

Figure 4. Arrangement of repeated dotted motifs present on a printout from Epson AcuLaser C8500 color laser printer.

Figure 5. Arrangement of repeated dotted motifs present on a printout from Fuji Xerox DocuPrint C831 color laser printer.

Figure 6. Arrangement of repeated dotted motifs present on a printout from RICOH AP305 C2000 color laser printer.

RICOH AP305 C2000 color laser printers respectively.

Results

Dotted Patterns on Color Laser Printouts

The printouts made by the two models of Canon color laser printers gave different motifs with different spatial arrangements (Figures 1 and 2). However, each unit of the repeated patterns on the printouts from both models was comprised of 18 dots, which is identical in the number of dots in the repeating units on photocopies generated by Canon color photocopiers (Li and Leung, 1998). Sample printouts from six Canon CLBP360PS color laser printers bearing different serial numbers were also obtained. Each unit of the repeated patterns on the printouts was also comprised of 18 dots, but with different spatial arrangements. As an illustration, Figure 7 shows the dotted patterns found on sample printouts from two of the Canon CLBP360PS color laser printers bearing different serial numbers. It is evident from the above findings that different color laser printers of the same model give different patterns. Following the same line of discussion as for color photocopiers (Li and Leung, 1998), we have come to the conclusion that patterns with distinctive arrangements of dots are related to the serial numbers of the machines and could be used for identifying the laser printers.

The patterns on printouts made by the Epson color laser printers were found to display two distinct arrangements. The repeated patterns on the printouts generated by the Epson AcuLaser C2000 color laser printer (Figure 3), each comprising 30 dots, were more complex in shape than those prepared with the Epson AcuLaser C8500 color laser printer (Figure 4). For the Epson AcuLaser C8500 printer, each unit could be accommodated within an imaginary unit comprising an 8-inch by 15-inch matrix which was similar to the unit cell on the color photocopy generated by the Rank Xerox A-color 635 color copier (Li and Leung, 1998). Not all of the imaginary crosses in the matrix were occupied by yellow dots, thus allowing variability and individuality for other possible models.

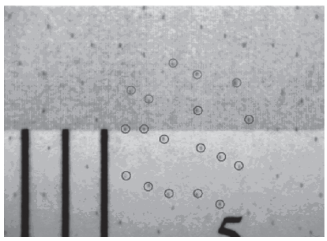

Figure 7a

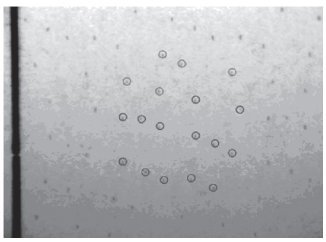

Figure 7b

Figure 7. Arrangement of the dotted patterns found on the sample printouts from two of the Canon CLBP360PS color laser printers bearing different serial numbers.

The patterns on printouts made by the two models of Fuji Xerox color laser printers (Figure 5) illustrate the pattern on Fuji Xerox C831 printer comprised an 8-inch by 15-inch matrix which was similar to the unit cell on the color photocopy generated by the Rank Xerox A-color 635 color copier (Li and Leung, 1998). The repeated units on the RICOH AP305 C2000 color laser printer (Figure 6) were comparatively simple in shape, consisting of two dots with a regular spatial arrangement.

The different patterns shown by different brands and models of laser printers provide an aid for nondestructive identification of some brands of color laser printers. Their presence on a questioned document allows the document examiner to identify the printer used for preparing the documents.

Raman Spectroscopy of Color Laser Printer Toners

Various authors have reported the use of infrared spectroscopic methods for the examination of toner particles of photocopiers (Merrill, Bartick, and Mazzella, 1996; Mizrachi, Aizenshtat, Levy, and Elkayma, 1998). Such methods involve the use of destructive means for the collection of toner particles from sample printouts. The latest Raman spectroscopic technology accommodates the excitation laser light source and its light path in a probe-like microscope with the viewing area reduced to micrometer dimensions. Using this approach, a nondestructive surface analysis with direct examination on the questioned documents can be achieved. Moreover, the technique minimizes tedious and time-consuming sample preparation procedures necessary for other instrumental techniques and will not cause damage to the documents. Raman spectroscopic analyses have been conducted on ink samples from documents (Claybourn and Ansell, 2000), and their results showed the possibility of distinguishing samples of different commercially available black ballpoint inks. Toner particles are the color materials used by color laser printers for the generation of color images. Therefore, the utilization of Raman spectroscopic method may provide a solution for nondestructive differentiation of color laser printers.

The four-color toners—namely, magenta, cyan, yellow, and black—generated from the Hewlett-Packard Color LaserJet 4500, Canon CLBP360PS, and Tektronix Phaser 740 color laser printers were analyzed by Raman spectroscopy. Figures 8a-d showed the Raman spectra of the four-color toners from the Canon color laser printer produced by the Renishaw Raman Microscope System 2000 with laser excitation wavelength l = 782 nm. The spectra of cyan and yellow toners (Figures 8a and 8b) displayed characteristic peak patterns. However, the magenta and black toners did not show any characteristic peak patterns (Figures 8c and 8d). The spectra of the four-color toners obtained from Hewlett-Packard and Tektronix laser printers showed patterns similar to the corresponding color toners of the Canon printers. Toners of the three brands of laser printers also generate similar spectra obtained under the laser excitation wavelength l = 514 nm. Hence, Raman spectroscopic analyses of the toners from the above three color laser printers did not give promising results on the differentiation of color laser printers.

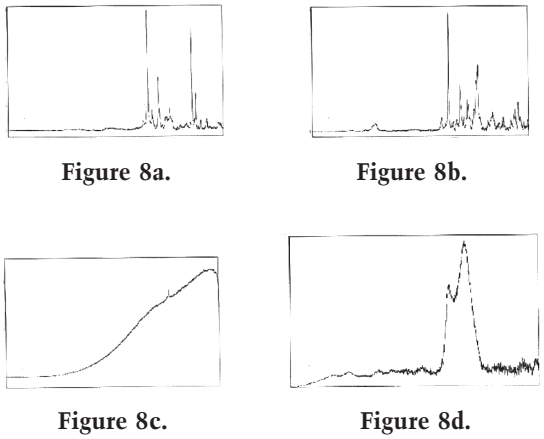

Figure 8a. **Figure 8b.**

Figure 8c. **Figure 8d.**

Figure 8. Raman spectra of (a) cyan toner, (b) yellow toner, (c) magenta toner, and (d) black toner from Canon CLBP360PS color laser printers.

Conclusion

Repeated dotted patterns could be observed using the VSC on the color laser printouts generated by color laser printers from certain brands and models. The data suggests that the patterns with distinctive arrangements of dots are related to the serial numbers of the laser printers. When conducting examination of questioned color laser printouts, document examiners should be aware of such dotted patterns on printouts and their association with color laser printers.

In our preliminary study, Raman spectroscopic analyses of color toner particles, though

nondestructive, cannot differentiate different brands of color laser printers. Further studies on Raman spectroscopy of sample printouts from other color laser printers and the use of another nondestructive method—reflective infrared spectroscopy—are in progress.

Acknowledgements

The authors would like to record here their gratitude to Dr. D. G. Clarke, Government Chemist of Hong Kong, for his interest and encouragement in this work.

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