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Application of Adobe® Photoshop® CC 2018 for Identifying the Source of HP® Color Laser Printouts



تطبيق Adobe® Photoshop® CC 2018 للتعرف على مصدر المطبوعات الليزرية الملونة لـ HP®

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Abstract

In today's digital world, printer forensics is one of the most important disciplines to reveal the authenticity of printed documents and track criminals. Digital steganography is an advanced approach to secure color laser printing processes, but it cannot be applied to monochrome laser printers. Therefore, the identity of the machine used to print color questioned documents provides a valuable means for detecting forgery crimes in digital forensic labs and law enforcement agencies. Based on this, we introduced a new forensic method that unveils the steganography (hidden information) embedded in color laser printouts via an adopted preset in Adobe® Photoshop® CC 2018. This forensic tool can be applied as a nondestructive and indirect tool for image processing. In the present work, printing, scanning, extraction, and measurements for the embedded tracking dots of candidate color laser printouts were conducted.

Thirty-five HP® color laser printers were selected with different and same models with different serial numbers and used to print a hundred color laser printouts.

The defined coded dots matrix patterns that characterized the color laser machines of the HP® brand could clearly be determined.

Therefore, this procedure could successfully be applied to distinguish between various color laser printouts printed by HP® printers with a variant serial number in digital forensic labs with a conclusive accuracy ratio attained to one hundred percent.

Keywords: Forensic Science, Digital Forensics, Color Laser Printouts, Tracking Dots, Active Technique, Adobe® Photoshop® CC.



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المستخلص

يعد حالياً التعرف على هوية وفردية الطابعات في العالم الرقمي أحد أهم المجالات الجنائية المستخدمة للتعرف على موثوقية المستندات وتعقب المجرمين. ويعد إخفاء المعلومات الرقمية طريقة متقدمة في تأمين عمليات الطباعة الليزرية الملونة والتي لم تتحقق في الطباعة أحادية اللون. ولذلك فإن التعرف على هوية الطابعة المستخدمة في طباعة المستندات المشكوك في صحتها واحدة من الوسائل التي تستخدم في كشف جرائم التزوير في المعامل الجنائية الرقمية وإنفاذ القانون.

في هذا العمل جرى تقديم أداة جنائية عن طريق كشف النقاب عن المعلومات المخفية المدرجة في الصفحات المطبوعة باستخدام الطابعات الليزرية الملونة ماركة اتش بي عن طريق اعداد مسبق لبرنامج أدوب فوتوشوب ٢٠١٨. وقمنا بتقديم تطبيق الأداة غير المباشرة وغير المتلفة لمعالجة الصور. وفي هذه الدراسة أجريت عمليات الطباعة والمسح الضوئي والاستخلاص وقياسات تتبع النقاط المضمنة للطابعات الملونة المستخدمة، حيث اختيرت خمسة وثلاثين طابعة ليزر ملونة ماركة اتش بي ذات موديلات مختلفة وأخرى متشابهة وجميعها تحمل رقم مسلسل مختلف وتمت طباعة مئة مطبوعة ملونة. وكنتيجة فإن نمط النقاط المضمنة المشفرة والتي تميز الطابعات تم تحديده بوضوح.

وعليه فإنه من الممكن تطبيق هذه الطريقة بنجاح للتمييز بين مختلف المطبوعات الليزرية الملونة ماركة اتش بي في معامل الأدلة الجنائية الرقمية بشكل قاطع وحاسم.

الكلمات المفتاحية: علوم الأدلة الجنائية، الأدلة الرقمية، طابعات الليزر الملونة، نقاط التتبع، التقنية النشطة، أدوبي فوتوشوب.

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1. Introduction

Digital forensic science is a broad field that also encompasses the identification of the source of color laser printouts. Nowadays, there are various methods of identification. These methods can be divided into different categories: statistical analysis, halftone analysis, and noisy features analysis [1-4]. All these methods have provided good results in the identification of printout sources but have not achieved an accuracy ratio of 100%. Therefore, to prevent or combat the increasing rate of forgery via color laser printers such as invoices, money, tickets, fraud ID, and contracts and certificates, we need to identify the source of these color laser printouts with an acceptable accuracy ratio [3-5]. However, passive techniques aiming to use imperfections generated by optical, electrical, or mechanical defects in machines were not satisfactory when tested and did not enable detection with an acceptable accuracy ratio [5].

On the other hand, there is an active technique that aims to track extrinsic features embedded in color printouts of machines [6]. An active technique tracks features in the form of yellow dots. These yellow dots are called machine identification codes (MIC), counterfeit protection system (CPS) codes, and coded dots matrix (CDM) patterns [7]. The tracking dots are very small in size and cannot be seen by the naked eye [8]. The tracking of these yellow dots is the authorized source of information about color laser machines, such as serial number, model, and in special cases, the date and time of the printing processes. So bearing this in mind, we applied the active technique in our paper.

In our work in this paper, we presented a nondestructive and indirect technique by Adobe® Photoshop® CC 2018 in the RGB mode for image analysis to detect extrinsic features of color laser printouts. We studied one hundred color laser printouts from thirty HP® color laser printers with the same and different models. The target goal in this study was achieved when we combined questioned color laser printouts with the defendant printer.

2. Materials and Methods

In this procedure, we followed the steps in Figure- 1.

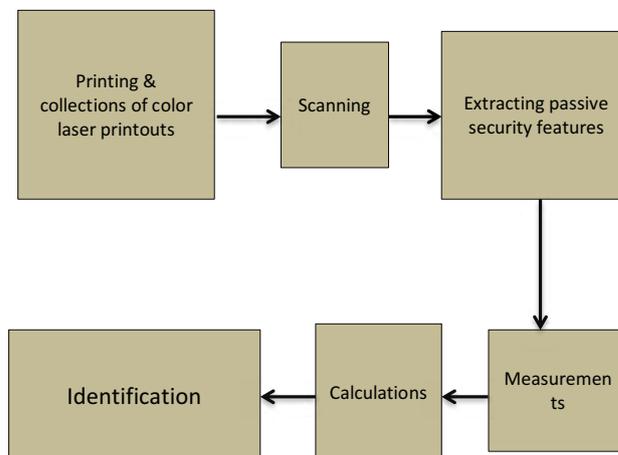


Figure 1- The authorized steps of a conclusive forensic technique procedure.

2.1. Printing and Sample Collection

White papers of A4 size were selected for printing color laser printouts. We collected the printouts from different work offices. In this study, we worked on the HP® color laser machines. The details of the studied models are given in Table-1.

Table-1: HP® printer models used in the study.

No.	Printer model	Number of Printers	Number of color laser printouts
1	HP Color LaserJet 4700	7	20
2	HP Color LaserJet CM4730MFP	5	11
3	HP Color LaserJet 4650	3	9
4	HP Color LaserJet 3600	3	9
5	HP Color LaserJet CP3505	2	6
6	HP Color LaserJet CP3520	4	12
7	HP Color LaserJet CP2025	3	9
8	HP Color LaserJet CM4730MFP	3	9
9	HP Color LaserJet CM4540MFP	3	9
10	HP Color LaserJet CM2320MFP	2	6



2.2. Sample Preparation

All printouts were scanned by a Cano Scan® LIDE 120 at a resolution more than 800 dots per inch (DPI). Because of the nanosize of the coded dots matrix, the resolution was increased to an extent that yields more vivid images and enables easy extraction.

2.3. Extraction

In this step, we applied an indirect method to extract the coded dots matrix patterns (CDMP) for the candidate printouts as a soft copy (because a hard copy of the printouts was not used in the image processing technique). Adobe® Photoshop® CC 2018 was utilized as a tool for processing images. The RGB mode was selected to manipulate the scanned images.

2.4. Measurements

We measured all spaces around the basic coded dots matrix patterns of the undertaken printouts. We employed Adobe® Photoshop® CC 2018 for all measurements with magnification at 100% relative to the basic images. Furthermore, live measurements were carried out directly on the color laser printouts by using a digital microscope and were calibrated with the estimated measurements.

3. Results and Discussion

In the current work, one hundred color printouts were printed by thirty-five HP® color laser printers and multi-function machines, as shown in Table-1. All candidate color laser printouts contained both script and graphs. All color laser printouts applied in this study had characteristic tracking dots spread all over the printout surfaces. We directed toward determination for all distributions, defined configurations and various space measurements for the extracted coded dots matrix by Adobe® Photoshop® CC 2018. We could successfully track and extract the tracking dots

embedded on all color laser printouts investigated. The defined configuration and the regular distribution of the extracted tracking dots of HP® color laser printouts investigated are characterized by the following aspects:

1. Tracking yellow dots were distributed and aligned in a regular grid of dots with horizontal rows and vertical columns.
2. There is a basic core unit repeated with the same configuration composed of sixteen columns with twenty rows (16*20) in a form of the coded dots matrix.
3. For each basic core unit of the repeated coded dots, the matrix was surrounded with four triangle shapes at its corners.
4. Coded dots matrix patterns were grouped horizontally in a form of sixteen rows with fourteen repetitions.
5. Coded dots matrix patterns were grouped vertically in a form of fourteen columns with sixteen repetitions.
6. For an individual color laser printer or a multifunction printer, there is a unique distribution inside the defined coded dots matrix pattern.

The defined configurations of HP® color laser printers and their different distributions can be seen clearly in Figures-(2-4) in both CMYK and RGB modes.

In Figure-2 above, we noted that the repeated basic unit of tracking dots is separated from other basic units by three constant dots at each of the four corners of the coded dots matrix (as shown in the four green squares).

For the same and different models of HP® printers investigated in this study, we found that the coded dots matrix patterns differ only in the distribution inside the defined pattern. However, all models that are investigated have a constant distribution of the tracking dots at the first five rows only of each basic coded dots matrix pattern as



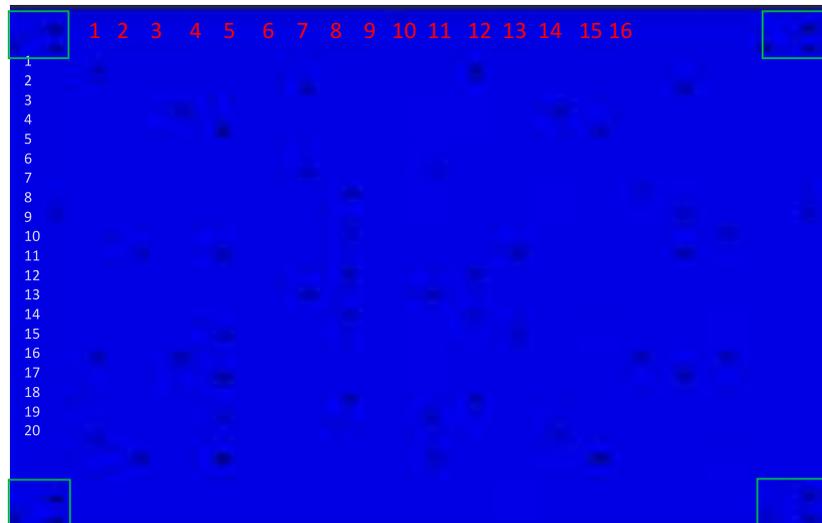


Figure 2- The repeated basic unit of tracking dots (black color) on an HP® LaserJet 3600 sample in the RGB mode.

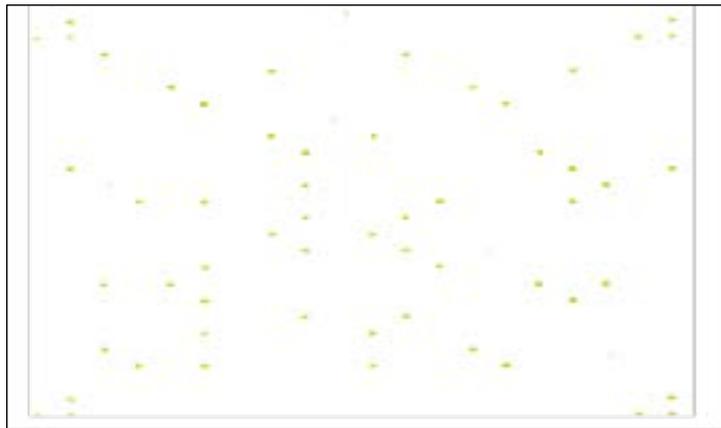


Figure 3- The active yellow dots spread and grouped as a regular grid pattern in horizontal rows and vertical columns on an HP® LaserJet 3600 sample in the CMYK mode.

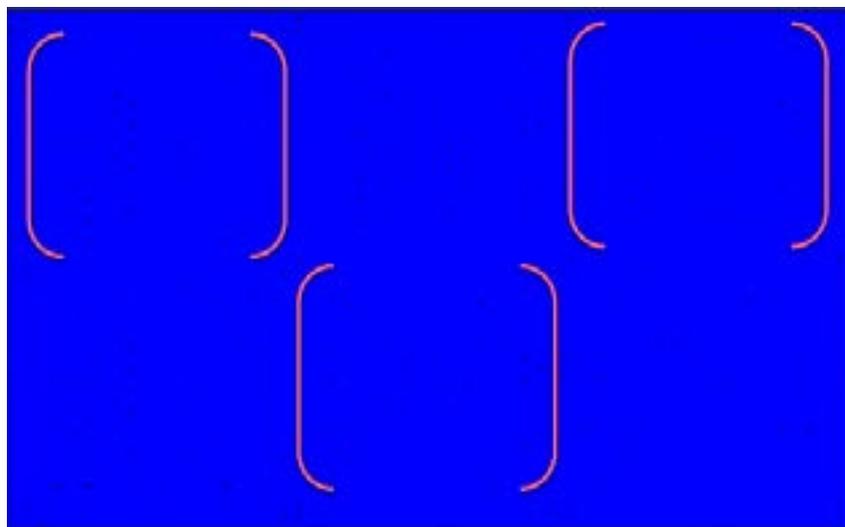


Figure 4- The representation of the spread and grouped tracking dots in a regular repetition of grid pattern in horizontal rows and vertical columns for basic coded dots matrix in red brackets for HP® laser jet 3600 sample.

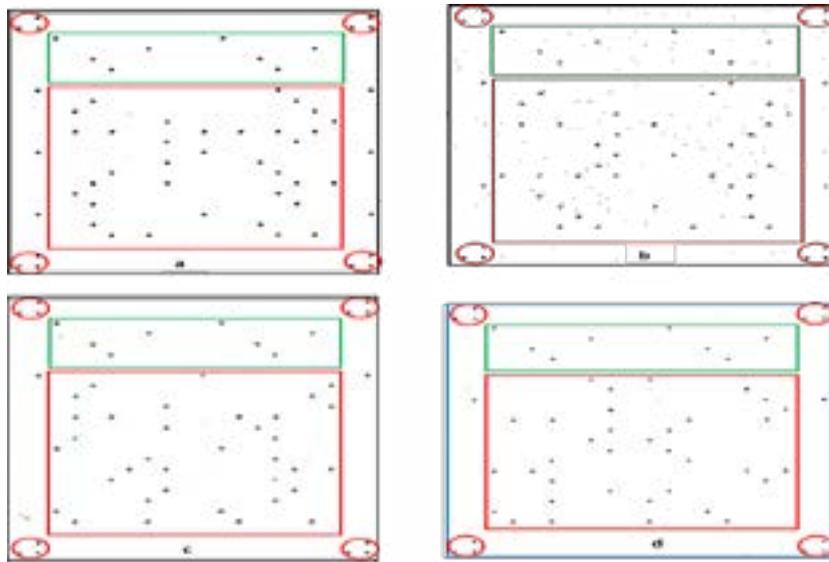


Figure 5- The representation of the different distribution inside the coded dots matrix for the same model of HP® 4700 color laser jet (a, b, c) and different model of HP® color laser 3600.

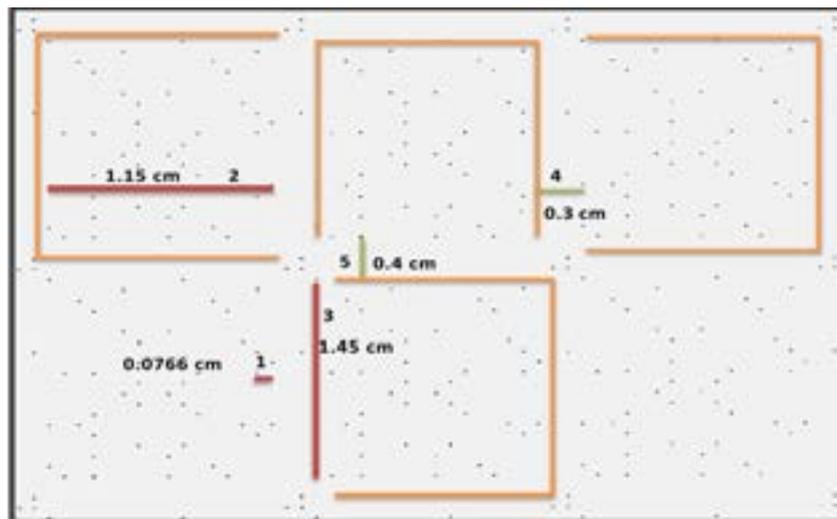


Figure 6- The five constant measurements (1,2,3,4, and 5) for the repeated basic patterns that exist horizontally and vertically of the coded dots matrix in an example of HP® color laser jet 3600 sample.

given in Figure-5.

As presented in Figure-5, we notice that the first five rows inside the coded dots matrix for the same and different models (rounded by green rectangles) are constant in their distribution; and afterward, the distribution in the rest of the rows are different (rounded by red rectangles). Therefore, we could determine the identity of the printer used from the first five rows of the coded dots matrix patterns and the uniqueness of each HP® color laser machine from the comparison of the dots distributed in the rest of

the coded dots matrix after the first five rows, as illustrated above (Figure–5).

Furthermore, we carried out all measurements for all spaces of the repeated basic units of the coded dots matrix printed onto each color laser printout undertaken in our study – including measurements surrounding the basic coded matrix pattern. Adobe® Photoshop® CC 2018 was employed as an analysis tool with a specific preset after calibration. We concluded that all color laser printouts investigated had invariant (space) distance measurements

that can be summarized as follows:

1. The interior distance between two adjacent dots of the basic coded dots matrix pattern was 0.0766 cm.
2. The basic coded dots matrix pattern width was 1.15 cm.
3. The basic coded dots matrix pattern length was 1.45 cm.
4. The distance that separated two adjacent repeated basic units of the coded dots matrix in each row was 0.3 cm.
5. The distance that separated two adjacent repeated basic units of the coded dots matrix in each column was 0.4 cm.

These measurements can be seen in Figure-6.

Moreover, the distribution of the yellow tracking dots inside the coded dots matrix for each HP® color laser printer did not change its position when we printed at variant intervals. We therefore determined that all the investigated HP® color laser machines contain a constant code of information that only reveals the machine serial number and the model type and that neither the printing time or the date was encoded in these coded dots matrixes.

4. Conclusion

We could successfully track, extract, and measure the spatial distances of the security feature embedded in all the HP® color laser printouts investigated using the conclusive preset of Adobe® Photoshop® CC 2018 with an accuracy of one hundred percent. The security feature embedded in all printout samples existed in the form of nanosized yellow tracking dots spread and grouped in a regular grid of dot patterns all over the printout samples as regular horizontal rows and vertical columns with consistency in both repetitions and spatial distances.

The basic unit of the tracking yellow dots that was repeated regularly was composed of sixteen columns and

twenty rows in a regular grid pattern with a unique and different distribution of yellow tracking dots inside them. We figured out each color laser printer or multifunction printer studied had the same first five rows that represented the identity of HP® brand but had its unique distribution of the tracking dots after the fifth row inside the coded dots matrix pattern. The coded dots matrix patterns of HP® printers are regular in their shapes and represented only the serial number with no information about the date or the time of the printing processes.

Therefore, in the current study, we presented a conclusive forensic technique for determining the printout sources of HP® color laser printers that distinguish between two or more color laser HP® printouts with a conclusive accuracy of one hundred percent.

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Conflict of Interest

None

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