

A Comparative Study of Different Printed Documents to Estimate the Type of Printer Used

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Abstract

Printer examination in questioned document examination has become a necessity in the present time due to the progressive use of printers in the creation of documents as compared to that of handwritten documents and also the counterfeiting of documents printed by different printers.

The present study is based upon the examination and analysis of different types of printed documents from various types of printers to distinguish and identify them for the purpose of forensic examination and to aid the questioned document examiner during the forensic analysis of cases involving such printed documents. Each printer has a unique fashion of printing documents and the aim of this research is to identify this fashion by examining the printed documents. The obtained results show a distinctive variation in the characteristics of the documents in respect to their ink types and character formation. This proves that the proposed technique is a useful tool to distinguish printed documents obtained from different types of printers. The printers that we used for analysis were an inkjet printer, laser printer and dot-matrix printer. Consequently, the above study can be applied in the field of forensic questioned document analysis, including investigation of the authenticity of documents.

Keywords: Questioned document; Printed documents; Types of printers; Class characteristics

Introduction

Forensic Science can be defined as the application of scientific knowledge and principles to legal problems and criminal investigations. It encompasses various fields of science, including anthropology, chemistry, medicine, physics, engineering, genetics, pathology, psychiatry, toxicology, etc. Forensic Science has played a pivotal role in solving crimes, ever since its inception. It helps the investigators answer questions which could not be answered otherwise. Forensic Science has several sub-branches that deal with diverse aspects of an investigation, one such branch is 'Questioned Documents Examination'. Questioned Document Examination

or QDE is an established field of forensics; it came into play early in this century as a means of forgery identification and authentication of disputed documents [1]. A questioned document is any signature, handwriting, typewriting, or other marks whose source or authenticity is doubtful or in dispute. Examples include letters, checks, driver licenses, contracts, wills, voter registrations, passports, petitions, threatening letters, suicide notes, etc. QDE is employed in cases such as forgery, counterfeiting, mail fraud, kidnapping, embezzlement, etc. [2]. Printing has become increasingly popular in the last few decades; printers are easily accessible and affordable, and almost every office and household have it. According to a study by Statistic Brain Research Institute in September 2016: 106 Billion printers are annually sold worldwide; the annual sales of Inkjet printers and Laser printers is \$18 Billion and \$30 Billion respectively [3].

Additionally, printed documents are some of the most commonly encountered evidence in QDE. People have become more aware of the different techniques used in solving crimes. Particularly speaking in the context of QDE, people now know how handwriting is individual and can easily be detected and matched to the original writer. Therefore, to avoid getting caught, culprits try using alternative ways that do not involve them to use their hand writing, one such method is using printed documents. Instead of writing a threatening letter by hand, a criminal will type out the letter and print it out, to minimize his chances of getting caught. Furthermore, legal documents like contracts, wills, passports, etc. and other important documents like bank statements, checks and other official documents are vulnerable to forgery where the printed text is usually targeted. Hence, printed documents are of great forensic importance and more research needs to be done in this field.

Inkjet Printers and Its Printing Process

Inkjet is basically a print head that moves back and forth while the paper moves through the carriage and basically sprays ink onto the paper. It sprays liquid ink on the media. It is used for oversized printing, for pictures that require more accuracy in color (like HD pics) and for printing on special media. An inkjet printer consists of three principle components: the printer head, the carriage and the advance mechanism. The print head is fixed to the carriage and fires ink onto paper while the carriage moves back and forth in the scan direction.

Laser Printers and Its Printing Process

Laser printer uses electrostatic digital printing which allows the production of high- quality texts and graphics, and moderate quality photographs. The process is carried out by passing a laser beam back and forth over the negatively charged cylinder called the “drum”, it then selects and collects the electrically charged powdered ink toner and transfers the image to the paper, which is then heated to permanently fuse the text and/or imagery. Xerographic printing process is adopted by laser printer. Laser printers adopt the following print mechanism -First, the laser scanner develops the image and then creates a beam of it which is directed through the glass window for copying the image, beneath. A mirror in the printer reflects this image and a lens focuses it. The image is transferred onto the photocopier belt and a developer unit converts the image into printable form. The printable image is transferred to the paper. The fuser permanently seals the image onto the page, which emerges into the collecting rack at top of the machine.

However, laser printing is different from analogue photocopiers. In laser printer, the image is produced by the direct scanning of the medium across the printer’s photoreceptor. This enables laser printing to copy images more quickly than most photocopiers. Laser printers are preferred in an office environment as the cost per copy is a lot lower with a laser printer, they are also quicker and quieter.

Dot Matrix Printers

Dot Matrix printer, also known as Impact Matrix Printer is a type of computer printing wherein a carbon ink ribbon is pressed against the paper to produce characters. It is similar to a typewriter in principle, but differs in the fact that the characters are produced and shaped in the form of dots by metal needles present in the print head.

There are two types- Serial Dot Matrix Printers (use a print head) and Line Dot Matrix Printers (use a hammer bank or print shuttle). The dot matrix printer has a print head that uses needle pins, located in the central position, to punch out the text onto the paper. It then moves back and forth as well as up and down to produce an entire character. Whilst the print shuttle has hammers arranged in a horizontal row but works in the same manner as a print head.

When switched on, the power goes into the electromagnets present inside the print heads. This creates an electromagnetic field. The magnets then press onto a tiny lever inside the print head which in turns hits the base of the needle. The metal needle moves up and down, bends and aligns with the actual printing head. As the needle moves out, it hits a carbon ink ribbon, present between the print head and the paper. The needle picks up the ink and deposits it onto the paper in the form of dots. Once the ink is deposited, the print head then moves a dot space/width apart to create an image. This process is carried out to form a complete letter or number. The ink ribbon always moves in the process, so that there is the adequate amount of ink that can be deposited onto the paper. The roller present inside the printer then advances the paper to print out other dots/characters.

There are two very important characteristics for dot matrix printers- the speed and print quality. The speed varies from 50-500 characters per second (cps) and 500-2000 lines per minute (lpm). Most dot-matrix printers offer different speeds depending on the quality of print desired. Whereas for print quality, the resolution of the printer depends on the pins used. For example, a 9-pin printer has lower resolution (60 dots per inch) compared to a 24-pin printer (216 dpi). Moreover, the dot matrix printer has a lower resolution has compared to the inkjet or laser printers.

Dot-matrix printers are no longer commonly used; however, they can still be found in banks, garages, workshops, factory floors and voting/ticket machines.

Materials and Methods

Aims and Objectives

A comparative study of different printed documents to estimate the type of printer used for identification in the civil and criminal cases encountered.

Assumptions

Each printer has a unique style of printing documents. This factor can be used to examine and trace the printed document to the type of printer used. Thus, considerable variation is found between a document printed from inkjet, laser and dot-matrix. This distinctive variation in the characteristics of the documents in respect to their ink types, and indentations will be obtained which shows that the proposed technique can be used to distinguish different printed documents obtained from different types of printers.

Hypothesis

1. The characteristic features of printed matter on the document in respect to different types of printers will be distinguishable and identifiable and can be correlated to the type of printer to a certain extent.
2. Despite variations observed in the documents printed from the same printer type, some features remain consistent and can be classified as their individual characteristics.

Samples

Sample Size -100

Samples Collection

Inkjet Samples: 40 samples were collected from 2 types of inkjet printers using the same printing medium (A4 size 21x29.7cm BLANK PAPER- "NCR Super Bright, 80GSM, "W/F WHITE LASER PAPER", 80 GSM). The "CLASS OF '16 LETTER" was used as the reference material for obtaining the samples.

The two printer models used:
HP Deskjet Ink Advantage 3635
Canon Inkjet MP 495

Laser-jet Samples: 40 samples were collected from 2 types of laser printers using the same printing medium (A4 size 21x29.7cm BLANK PAPER- "NCR Super Bright, 80GSM, "W/F WHITE LASER PAPER", 80 GSM). The "CLASS OF '16 LETTER" was used as the reference material for obtaining the samples.

The two printer models used:
HP Work Force Pro WF-R8590
Image Runner Advance Canon

Dot Matrix Samples

A limited number of 20 samples were collected from 2 types of Dot-Matrix printers.

Inclusion Criteria

- The same printing medium - A4 size 21x29.7cm BLANK PAPER- "NCR Super Bright, 80GSM, "W/F WHITE LASER PAPER", 80 GSM -was used.
- The "CLASS OF '16 LETTER" was used as the reference material for obtaining the samples.
- The main body of writing was printed out using the same format- Calibri (body), size 12, alignment justified; whereas the heading of the reference material used the same format- Calibri (body), size 14, alignment centre.
- As dot matrix printers are rarely used we had to restrict our research on few samples. The samples obtained were
1) Receipts from an automobile repair workshop-Al Rashidiya Workshop, Mercedes-Benz, Gargash Enterprises.
2) Checks from Emirates NBD.
- The printed text was not constant for the Dot-Matrix samples.
- Properly functioning printers were used.

Exclusion Criteria

- Use of different paper texture to print the given material
- Use of different fonts, sizes and alignment to format the reference material
- Use of images
- Printing the material in different colors
- Use of malfunctioning printers
- Use of torn or damaged papers

Sample Analysis (Parameters)

- Resolution of the printed letters (Print Quality)
- Feature detection
- Degree of edge contrast
- Degree of edge roughness
- Spur marks (Tremorous printing)
- Smoothness of ink flow
- Uniformity of printed character area
- Variation in style and alignment

Equipment Used

- Inspec8-Document Examination Machine
- Stereomicroscope

Outcomes

The result obtained can be used in the forensic analysis of questioned documents to differentiate a forgery from a genuine document as well as in narrowing down the type of suspected printer used to further help and provide links in any investigation.

Result and Discussions

Inkjet Document

- Resolution: The letters in both the Inkjet printer samples had a lower resolution and clarity (Figure 1 and Figure 2).
- Feature detection

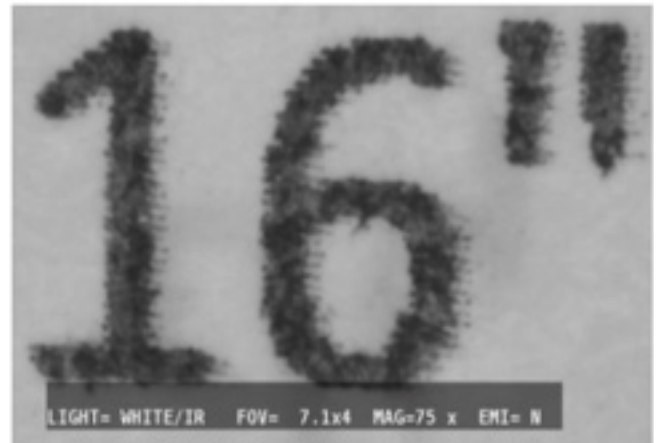
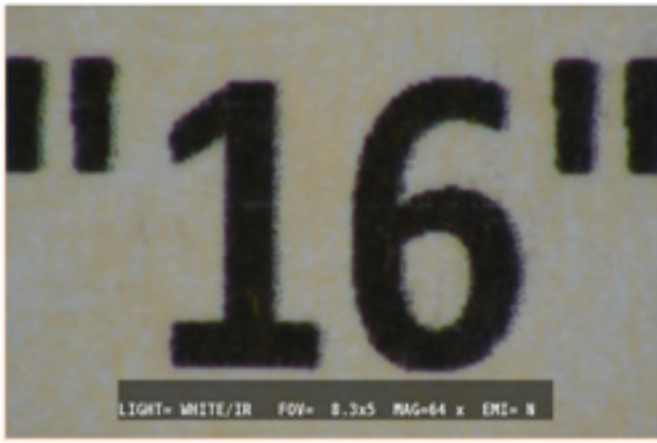


Figure 1 - The number "16" from the Canon Inkjet (Left) and HP Inkjet (Right)

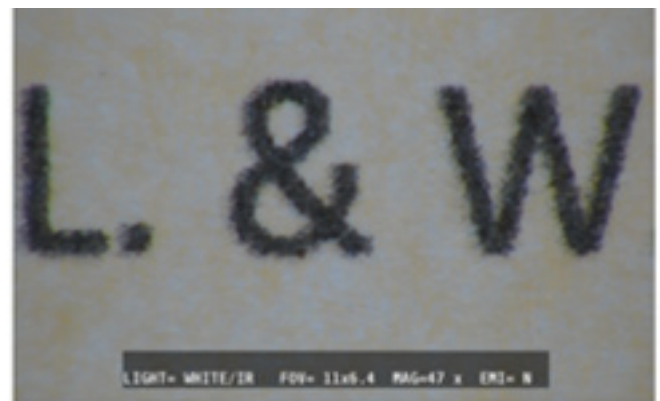
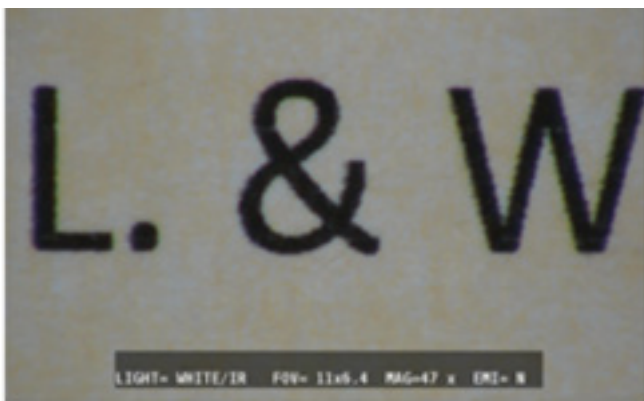


Figure 2 - The letters "L. & W" from the Canon Inkjet (Left) and HP Inkjet (Right)

Degree of edge contrast

The letters had a low degree of edge contrast and the edges had the appearance of smudging in the background.

Degree of edge roughness

The edges of the letters were uneven and rough. Under high magnification, the borders of the letter looked degraded.

Spur marks

An inkjet printer works by firing drops of ink onto paper when the print head is moving. As a result, tails or satellites of the ink drop are formed on the document, and the contours of the printed characters are rough and contain ups and downs. Spur marks were present in the Inkjet letters; they differed in pitch and mutual distance.

Smoothness of ink flow and uniformity of printed character area

In the letters, spraying of liquid ink was quite evident as there were signs of blotting on the paper.

The inking was not consistent throughout the letter; i.e. some places of the letter had more inking while some places had less inking.

Due to uneven inking of letters, the areas with more ink appeared darker which in turn gave an overall appearance of dark spotting within the letter.

The letters in the text displayed signs of a slow speed printing technique.

LaserJet Document Resolution

The letters in the Laser printer samples had a higher resolution. They were more crisp and sharp (Figure 3 and Figure 4).

Feature detection

Degree of edge contrast

The letters had a better edge contrast than the letters in Inkjet samples.

Degree of edge roughness

The boundaries of the letters were much sharper and significantly refined.

Smoothness of ink flow and uniformity of printed character area

The ink deposition in the letters was uniform giving a smooth border.

The letters possessed a considerable thickness, due to more spraying of ink.

The letters depicted the use of a faster print technique.

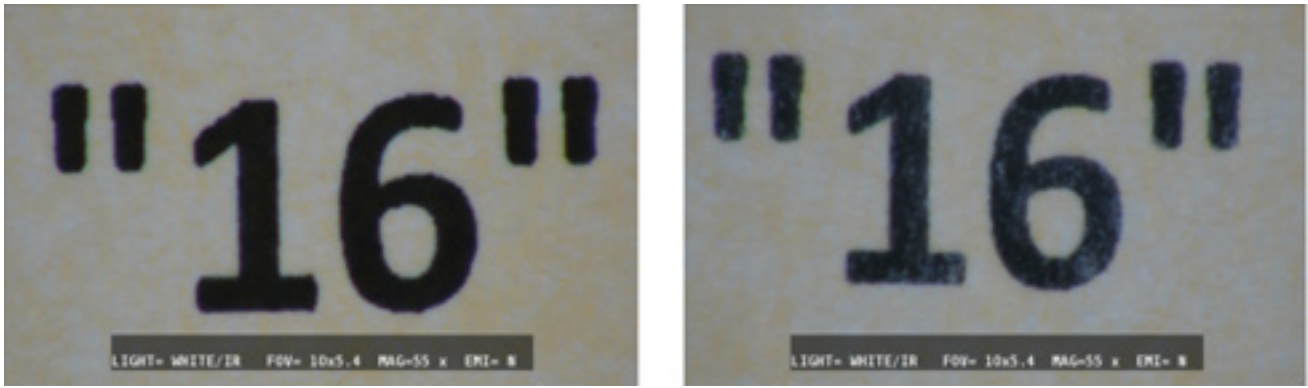


Figure 3 - The number “16” from HP Laser (Left) and Canon Laser (Right).

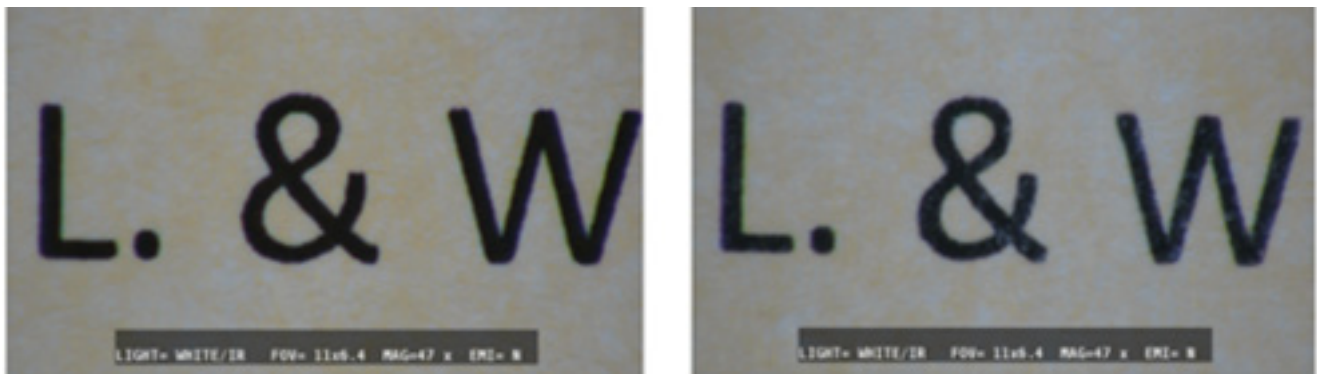


Figure 4 - The letters “L. & W” from HP Laser (Left) and Canon Laser (Right)

Dot Matrix Document

From the three printing techniques, the Dot-Matrix printer has the most unique and peculiar way of printing the letters. The fashion of printing the letters makes the printer easily identifiable (Figure 5 and Figure 6).

The following characteristics were observed.

The letters in Dot-Matrix printers appear as a cluster of dots; each dot in the letter is partially or absolutely separate from the others (depending on the brand of printer).

The inking in the letters is discontinuous; this made the letters look incomplete upon magnification.

The cluster of dots was mostly present in places where the alphabet curved; e.g. the curves of ‘S’, the semi-circle of ‘D’, etc. In non-curving regions, the lines of the alphabets were straight and without dots.

Each group of dots formed a zig-zag pattern within the letters.

Inkjet vs. Laser

Below is a comparison between the class characteristics of Inkjet printed documents and Laser printed documents. The Dot-Matrix printer has not been included in the comparison as its identification parameters are different and peculiar (Table 1).

Conclusion

The basis for printer identification allows law enforcement agencies to trace the origin of fraudulent documents to the suspected printer which will ultimately point to the owner and/or suspect(s). Thus, the result obtained in this study could be potentially useful in criminal investigations as corroborative evidence.

Firstly, the study can be applied in secured document analysis to check for forgery as most of the passports and other security documents are printed using Laser printers [4]. If a microscopic examination of the formation of letters is carried out, in addition to the other passport-related examinations, it can aid the investigators to reach a more specific and accurate conclusion. Secondly, Banknotes & Checks, too, adopt a specific printing technique in their text. To check their authenticity, the questioned documents can be compared with the standards microscopically and the formation of letters can closely be examined to establish a match or mismatch of the printing techniques.

This study can also be applied to the examination of alterations and additions in disputed printed documents. Official documents are often prone to be forged by making alterations, additions or deletions in the text of the document. If such a document is in dispute, then the words of the document which are thought to be altered can be compared with the text of the original document, to identify if the printing techniques match. If the printing techniques match, then the individual characteristics of similar letters can be compared.

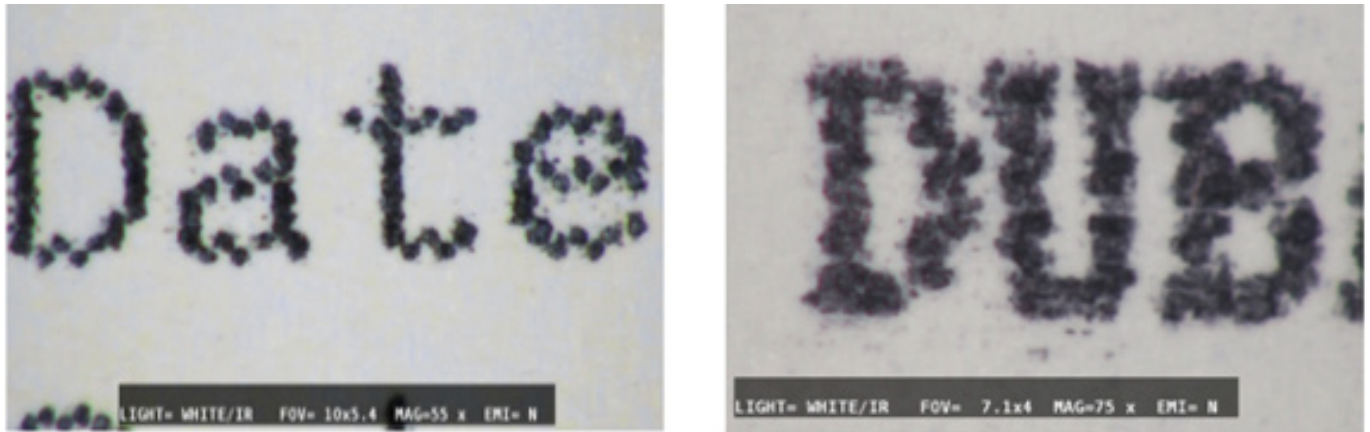


Figure 5 - Some letters from dot-matrix receipt (Left) and check (Right).

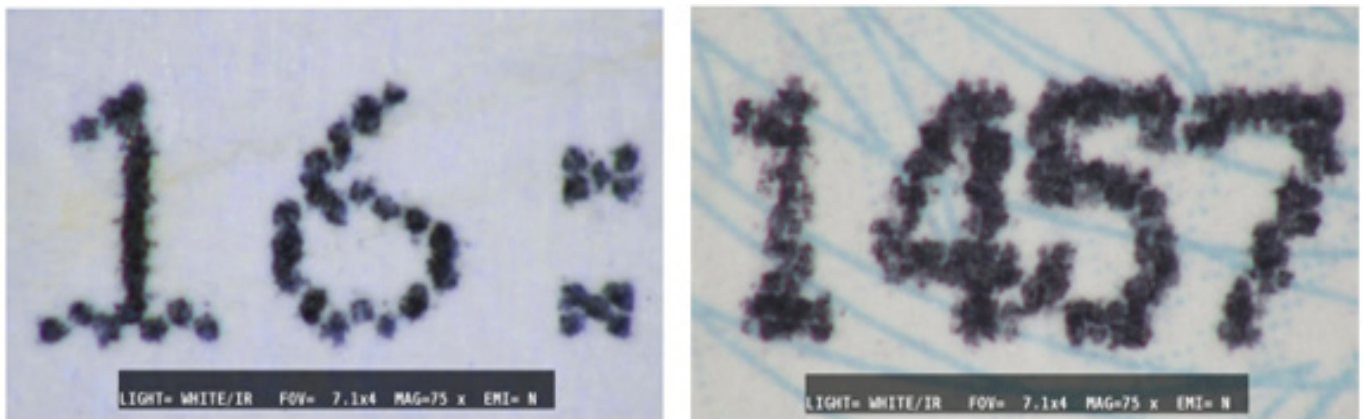


Figure 6 - Some numbers from dot-matrix receipt (Left) and check (Right).

Characteristics	Inkjet Printer	Laser Printer	Dot-Matrix Printer
Overall print quality	Low	High	Moderate
Appearance	Contains satellites of ink drop (Spur marks)	Glossy	Cluster of Dots
Contours	Rough with ups and downs	Clear	Moderate
Edge Roughness	Uneven and rough	Sharp and Refined	Rough
Inking Uniformity	Inconsistent; spotting present	Consistent and uniform	Mostly consistent

Table1: Differences between Inkjet, Laser and Dot-Matrix samples.

Lastly, the result obtained makes it possible to narrow down the search for the type of suspected printer. For example, consider a situation where a threatening letter has been encountered in a case; this letter is printed on a standard white paper. The letter can be studied to find the type of printer used; this information can then be used to exonerate the printers which were earlier suspected to have been used by the perpetrator. Therefore, the printing technique used acts as a class characteristic: if the class characteristics do not match, then no further examination is required; however, if they do match, then the individual characteristics can be examined. Furthermore, the tracking of a suspect printer could be further improved by combining other printing features along with the presented features, thus encouraging further research in this field.

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