

## A Study of Certain Characteristic Features of Various Printed Documents To Determine The Type Printer Used in Forensic Investigations

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### ABSTRACT

Printed documents are very frequently encountered in forensic cases as disputed or questioned documents. With increasing number of such cases, the printer inspection in has become a major requirement in questioned document examination in recent years considering the extensive use printers in document creation in comparison to handwritten papers. Also, the counterfeiting of printed documents by various printers have been recorded at a large scale in last two decades. In such cases, it is very much required by the investigators to examine and identify the type of printer used and to establish a linkage of the questioned document with the alleged printer. The current study is focused on the examination, analysis and identification of various types of printed documents on the basis of their specific characteristics including resolution, edge contrast, letter roughness and feathering formed from diverse printers to differentiate and classify them for forensic questioned document examination and to assist the forensic expert and questioned document examiner thorough such investigations. In this study three types of printers i.e. two inkjet printers, two laser printers, and two different dot-matrix printers were used to collected the printed documents. The samples were analyzed using Projectina Inspec-8 and Stereomicroscope. Each printer has its uniqueness in printing documents, and this study aims to figure out that particular uniqueness at the documents after printing from the alleged printer. The observations revealed substantial differences in the letter's characteristics. This study may be a useful to discriminate the documents printed from different types of printers.

**Keywords**— Printed Documents, Disputed Documents, Printers, Questioned Document Examiners, Types of printers, Uniqueness of Printers

### I. INTRODUCTION

Forensic Science and its sub-domains have always played a crucial role in the investigation of various crimes. It aids investigators in answering questions that would otherwise be impossible to answer [1]. Questioned Documents Examination is one of the sub-branches of forensic science that deal with various aspects of investigation regarding disputed handwritings, signatures, forgeries, disguises, and other fraudulent document examination [2]. Questioned Document Examination is a well-established field of forensic science that was first used in the early twentieth century to identify forgeries and authenticate disputed documents [3]. Any signature, handwriting, typewriting document, a printed document, or symbols whose authenticity or source is in question are considered as questioned or disputed documents. Bank checks, Anonymous letters, disputed contracts, wills, passports, petitions, threatening letters, and suicide notes are some examples [4]. In the last few decades, printing has become increasingly popular; variety of easily available and inexpensive printers are encountered at every work place and household now a days [1, 5]. As per a study released by the Statistic Brain Research Centre in September 2016, “106 billions of printers are sold globally each year and as per data available the annual sales of inkjet printers and laser printers are 18 billion USD and 30 billion USD, respectively” [6]. Furthermore, printed documents are very frequently encountered evidence in several cases of frauds, forgeries, and other white collar crimes. Population, in general, is becoming more conscious about the various methods and techniques used to solve various types of crimes including frauds and forgeries [7]. General population currently have a better understanding of how handwriting is different in each and every individual and can be easily recognized and matched to the original writer, which is especially important in the context of QDE. To prevent being captured, criminals use alternate techniques that do not require them to use their handwriting, one of which is the use of printed documents. To reduce the likelihood of being caught, an offender may type and print a threatening letter rather than writing it by hand [8].

Contracts, property wills, country passports, bank checks, and other crucial documents are particularly on higher risk of forgery, in context of printed text. As a result, forensic investigations rely heavily on the inspection of printed documents, and further research is required in this area. The current research focuses on the analyses of characteristic features of different types of printed documents to differentiate them for forensic inspection and to assist the forensic experts and questioned document examiners during in identification and examination of the type and make of the printer during such investigations. Each and every printer has a distinct style for printing the documents, and the main objective of this research is to determine that particular style on the printed documents. The results showed a significant difference in the letters (alphabets and numerals) characteristics, especially in terms of the ink types and character formation. The study may be useful for distinguishing disputed printed documents printed from various types of printers and their linkage to the alleged printer. Previously many researches have been done in the area of print quality, image processing, and image quality enhancement. In one the research the researchers have worked upon the Quality Attributes (QAs) for reducing uncertainty and bridging the difference between subjective and objective quality evaluation (QAs) of the print quality. According to them the QAs include terms like lightness, saturation, and information, which are all terms of perception. They aid in the reduction of Image Qualities (IQ's) complexity, as well as its dimensionality, when combined with a well-defined set of attributes [9]. In a separate report, researchers developed a bioinspired expert system for printer forensics that combines texture features derived from the grey level cooccurrence matrix of the printed letter 'WOO' with niching genetic quest to pick the best reduced feature set. This combination relies on a small number of discriminative descriptors to achieve high classification precision [10]. In another research the examiners examined print patterns of eight different inkjet printers. Using Principle Component Analysis, they looked at the data's characteristics by reducing its dimensions. Their research demonstrated a major difference between printers, implying that the Deep Neural Network and was able to detect important differences. The findings were also comparable to those obtained by using Linear Discriminant Analysis to reduce dimensions [11].

In current study, two inkjet printers, two laser printers, and two different dot-matrix printers were used. There are currently many printers on the market that have the ability to print documents at a much higher speed per minute, with better quality, and at much lower prices. Many of them are not in use in present scenario and some of them are still ruling the markets. Few of such printers are:

#### *A. Working of Inkjet Printer*

Inkjet printing is quite common and employs a swinging print head that sprays ink onto the paper as it travels through the carriage [9, 10]. It's used for printing on large scales, images that need more color fidelity (such as HD photos), and printing on certain special media. Any inkjet printer has three major elements i.e. the printer head, carriage, and advance mechanism. As the carriage swings back and forth in the direction of scan, the fixed print head fires ink onto paper.

#### *B. Working of Laser Printer*

Laser printers use electrostatic digital printing to generate high-quality tests and graphics, as well as moderate-quality images. Over a negatively charged cylinder known as the drum, a laser beam passes back and forth which the charged powdered ink from toner is selected and then collected electrically before transferring the image on to the paper, which is then printed [10]. The xerographic printing method is used by laser printers. The printing process begins with the work of a laser scanner, which forms an image and then generates a laser beam which is then directed through the glass interface to replicate the image underneath it. A mirror located in the printer then reflects this image, which is centered on a lens. The image is moved to the photocopier belt, where it is converted into printable form by a developer device [11]. Laser printing, on the other hand, differs from analogue photocopiers. The image is created in a laser printer by scanning or imaging the medium directly across the photoreceptor of the printer. As a result, laser printing can copy and print images much faster than most printers and photocopiers.

#### *C. Working of Dot-Matrix Printer*

A Dot-Matrix printer, commonly known as an IMP (Impact-Matrix printer), creates characters by pressing a ribbon of carbon ink against the paper. It functions similarly to a typewriter, except that the characters are produced and formed as minute dots by metal needles in the print head [12]. Needle pins in the central position in the print head of a dot matrix printer are used to punch out any text onto the

page. Going back and forth, as well as up and down, creates the character [13]. The print shuttle, on the other hand, has a horizontal row of hammers and works similarly to a print head. Dot-matrix printers have two very critical characteristics: speed and print quality. The pace ranges between 50 and 500 characters-per-second (cps) and 500 and 2000 lines per minute (lpm) [14,15]. The speed of most dot-matrix printers varies depending on the print quality required. The printer's resolution is determined by the pins used. Furthermore, as opposed to inkjet or laser printers, the dot matrix printer has a lower resolution [16].

The distinct differences in the documents' characteristics in terms of ink types and indentations were obtained in the current work, demonstrating that the proposed methodology can be used to differentiate between various documents printed by various types of printers. The concept was based on the fact that, according to the law of individuality, every printer has their own way of printing documents with certain distinct characteristics [17]. This feature can be used to examine the printed document and trace it back to the printer that was used. As a consequence, a document printed by an inkjet printer, a laser printer, or a dot-matrix printer differs significantly [18].

## II. MATERIALS AND METHODS

The current study's main goal was to forensically inspect various printed documents in order to determine the possible type of printer used in the creation of the document for identification in civil and criminal cases during questioned document examination. For this analysis, two major hypothesis were formed. Firstly, the recognizable and distinguishable characters of printed matter on the paper in relation to various types of printers to be compared to identify the type of printer used. Secondly, despite of variations observed in the documents printed from the same printer type, some features remain consistent and can be classified as per their characteristic features. These specific and identifiable characteristics of the printers can be considered as their personal "Autographs" in Questioned Document Examination.

A total 60 samples of black and white printed document were collected for the study. Out of which 20 samples were collected from two inkjet printers i.e. HP Deskjet - Ink Advantage - 3635 series and Canon Inkjet - MP 495 - model. The prints were taken on A4 size 21x29.7cm 80GSM white plain paper. 20 samples were collected from two different laser printers i.e. HP Work Force Pro WF-R8590 and Image Runner Advance Canon. 20 samples were collected from a Dot-Matrix printer. The documents were printed using the same format i.e. Calibri body style, 12 font size, justified alignment.

## III. RESULTS AND DISCUSSIONS

The printed documents were analysed using Docustat Inspec-8 for enlargement (75x magnification), image capturing under different wavelengths of light, and to decipher the individual microscopical features. The samples were studied for their print quality (overall resolution), letter contrast, letters edge roughness, presence of spurs, smoothness of ink flow, feathering in the character area. Table 1 shows the overall comparison of the characteristic features of the printed documents by three types of printers.

TABLE 1

Comparison of the characteristic features of the printed documents by three types of printers.

Comparison Parameters - As viewed in 75x magnification	Inkjet Printers	Laser Printers	Dot-Matrix Printer
Overall Print Quality (Resolution)	Medium resolution	High resolution	Low resolution
Letter Contrast	Lesser contrast in comparison to laser printer	Higher contrast in comparison to inkjet and dot-matrix printer	Least contrast comparatively.
Edge Roughness	Rougher edges	Smoother edges comparatively	Most rough edges and scattered letters
Presence of spur marks	Satellites of ink drops present	No spurs observed	Clusters of dots present

Feathering of letters	Feathered letters observed	No feathering observed	Most feathered letters observed
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From table 1 it is clear that in case of both the Inkjet printers, the samples had a medium resolution and clarity of the letters (figure 1a and 1b), higher resolution in case of laser printers (figure 2a and 2b) and least or blurred letter formation in dot-matrix printed documents (figure 3a and 3b). On observing the letter contrast the inkjet printers produces relatively lesser contrast images in comparison to laser, whereas dot-matrix printer printed least contrast letters with minimal ink shading. The edges of the letters were uneven and rough in case of inkjet printers, quite smoother in laser printer and comparatively roughest in dot-matrix printed documents. It was noteworthy that inkjet printer produces letters with spur marks (satellites of ink drops), whereas no spur marks were spotted in laser printing. However, as a highly characteristic feature dot-matrix printing was very peculiar producing dotted clusters to form a letter and can be easily differentiable with other two printers.

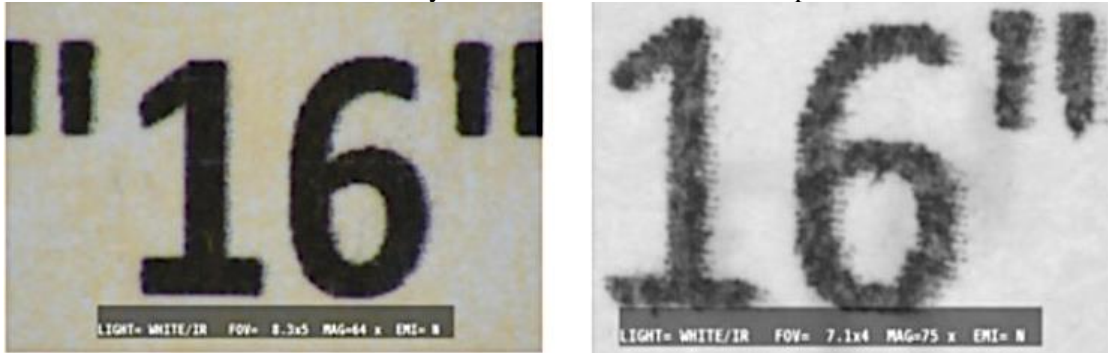


Figure 1

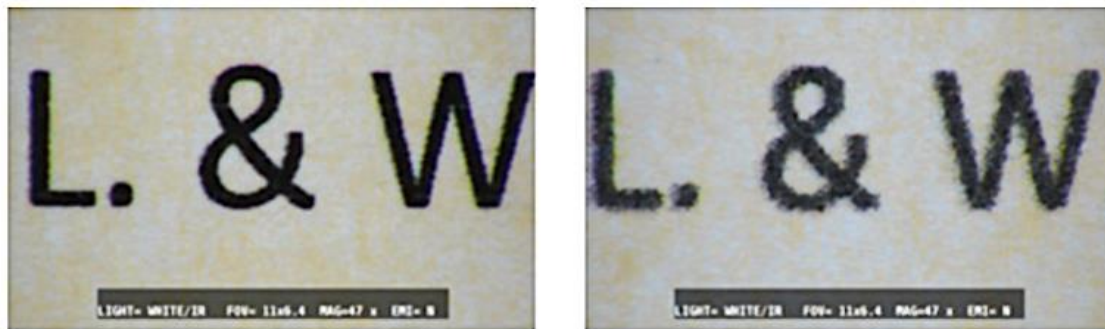


Figure 2

Fig. 1 and Fig. 2 Showing the letters printed with Canon Inkjet and HP Inkjet respectively. The enlarged images were captures using Docustat Inspec-8 under white light with a magnification of 75X.

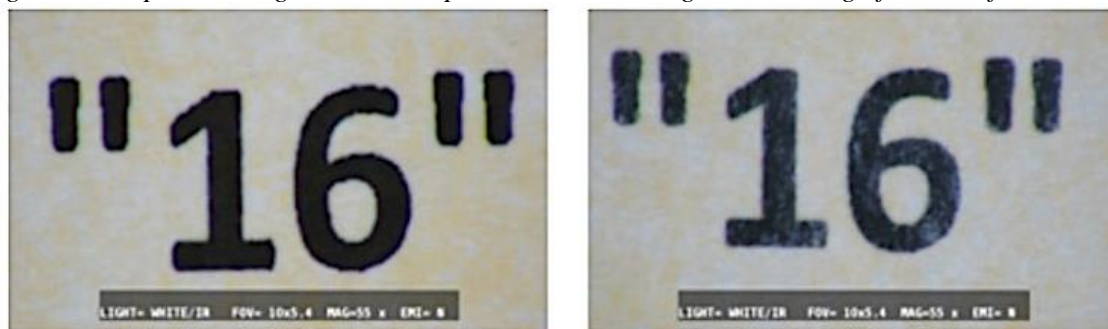


Figure 3

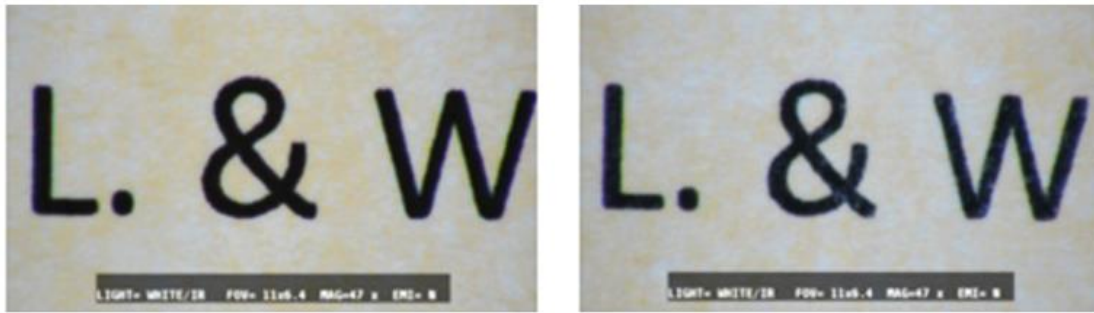


Figure 4

Fig. 3 and 4 Showing the letters printed with HP Laser and Canon Laser printers respectively. The enlarged images were captures using Docustat Inspec-8 under white light with a magnification of 75X

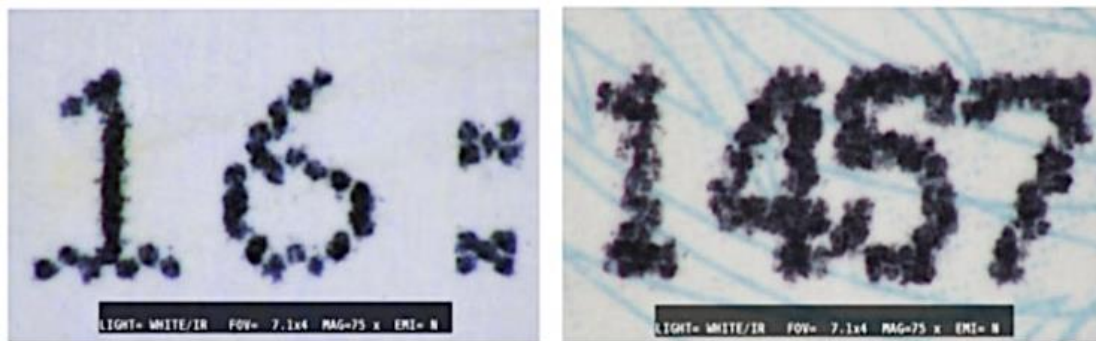


Figure 5

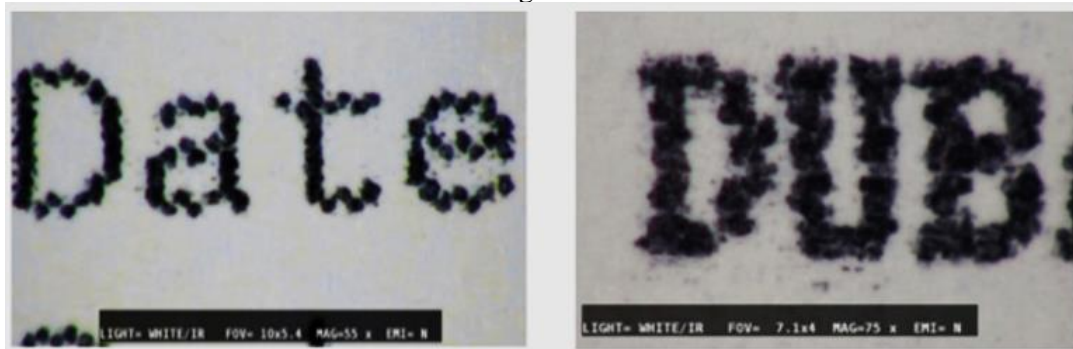


Figure 5

Fig. 5 and 6 Showing the letters printed with Dot-Matrix printer. The enlarged images were captures using Docustat Inspec-8 under white light with a magnification of 75X.

In practice, the document to be detected can be of low resolution; as a result, sensitivity to resolution is an essential measure of any forensics technique's success. In this work we checked the resolutions ranging from 200 to 600 dpi, which covers the most common resolutions. When the resolution is greater than 500 dpi, the accuracy of inkjet printer detection is stable. As the resolution exceeds 300 dpi, the accuracy of laser printer and dot-matrix detection improves gradually. It was observed that as soon as the dpi increases to 500 in case of dot-matrix printer, the resolution decreases almost to 50%. Whereas, it was observed that resolution increases with increasing dpi in case of laser printer documents. Inkjet printing is distinguished from laser printing and copying by roughness. Since ink drops are sprayed onto paper as the print head moves, tails or satellites trail the ink drop of the design processes in inkjet printing.

#### IV. CONCLUSION

Foundation for the identification of printer enables law enforcement bureaus to track the source of any fraudulently formed documents back to the alleged printer, which will eventually lead to the perpetrator identification. As a consequence, the findings of this study may be useful as a corroborative evidence in civil and criminal investigations in context to Questioned Document Examinations. Since most of the security documents are printed on Laser printers, the study can be used in the analysis of secured



document to search for any evidence of fraudulent activity where any other printer has been used and also in cases where two different laser printers have been used. In addition to this, a microscopic analysis of the shape of letters will help the investigators draw a more precise and reliable conclusion in suspected cases of frauds and forgeries. Secondly, the text on Banknotes and Checks is printed using a specialized printing technique. Though many of the researches have been done on handwritten and disguised materials previously [19]. Further, the challenged documents can be evaluated and compared to the criteria microscopically. The formation of letters can also be closely examined to determine whether the printing technique is a fit or mismatch. This study may also be used to investigate changes and modifications to contested written documents. Official documents are often forged by making certain modifications, additions, alteration, or deletions to the document's text. When a document is in question, the words that are believed to have been changed or modified may be compared to the text of the original document to see if the printing processes are the same or different. Individual characteristics of identical letters may be compared if the printing techniques are similar. Finally, the information collected will allow to narrow down the quest for the sort of printer that is suspected to print the disputed document.

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