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# An Examination of Inkjet and Laser Printed Documents using Stereomicroscope : A Forensic Approach

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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 64 types of printers i.e. 32 inkjet printers and 32 printers comprise 1024 printed documents were collected for the analysis. The samples were analyzed using Olympus stereo microscopes SZX16 (4x magnification). 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:** Forensic Documentation, Forgery, Inkjet, Laser, Stereomicroscope.

## 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 (QDE) is one of the sub-branches of forensic science that deal with various aspects of investigation regarding disputed handwritings, signatures, forgeries, disguises, and another fraudulent document examination. 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 [2]. 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 [3]. 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. As per a study released by the Statistic Brain Research Centre in September 2016, "106 billion of printers are sold globally each year and as per data available the annual sales of inkjet printers and laser printers are18 billion USD and 30 billion USD, respectively" [1, 3]. Furthermore, printed documents are very frequently encountered evidence in several cases of frauds, forgeries, and other white-collar crimes [4]. Population, in general, is becoming more conscious about the various methods and techniques used to solve various types of crimes including frauds and forgeries [5]. 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 [6]. 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 [7].

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 [4, 6]. 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 [3, 7]. 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 [8]. 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. In another research the examiners examined print patterns of eight different inkjet printers [10]. 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.

*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.

*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 cantered 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 [12].

## 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 hypotheses 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 1024 samples of black and white and coloured printed document were collected from 32 inkjet and 32 laser printers. 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 DISCUSSION

The printed documents were analysed using Olympus stereo microscopes SZX16 (4x magnification), image capturing 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 inkjet and laser of printers.

**Inkjet Document**

Resolution: The quality and clarity of the letters in both Inkjet printer samples were poorer.

**Features**

**Degree of edge contrast**

The edges of the letters had a poor level of edge contrast, and they appeared to be smearing in the backdrop.

**Degree of edge roughness**

The letters' edges were jagged and irregular. High magnification made the letter's borders appear deteriorated.

**Spur marks**

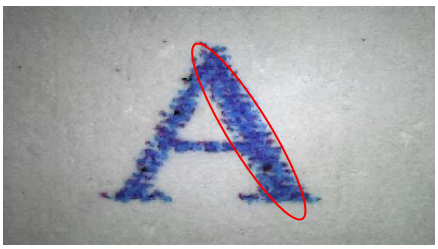
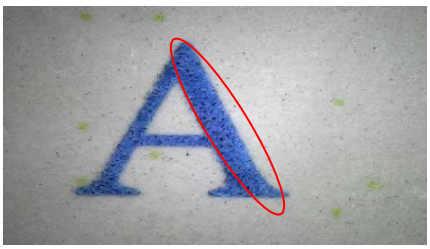
When the print head moves, an inkjet printer releases drops of ink onto the paper. The ink drop forms tails or satellites on the page, and the printed characters have uneven, up-and-down shapes as a result. The Inkjet letters contained spur marks, which varied in pitch and proximity to one another.

**Smoothness of ink flow and uniformity of printed character area**

The letters clearly showed indications of liquid ink spraying since the paper had been blotted. The inking was not uniformly applied throughout the letter; as a result, certain areas received more inking than others.

Because letters were inked unevenly, the places with more ink appeared darker, giving the impression that the letter had dark spots all over it. There were indications of slow speed printing in the text's letters.

**Table 1.** Overall comparison of the Inkjet and Laser printed documents

| Examination | INKJET | LASER |
|---|---|---|
| |  |  |
| **Degree of edge contrast** | Poor level-Blunted edge | Sharp and crisp edge |
| **Degree of edge roughness** | Irregular | Precisely defined |
| **Spur marks** | Present | Absent |
| **Smoothness** | Not uniformly present | Uniform border |

**Laser printer**

**Resolution**

The lettering in the examples from laser printers were sharper. They had a sharper, crisper edge.

**Feature detection**

**Degree of edge contrast**

In comparison to letters from Inkjet samples, the letters exhibited a stronger edge contrast.

**Degree of edge roughness**

The letter borders were much crisper and more precisely defined.

**Smoothness of ink flow and uniformity of printed character area**

The letters had a nice border because the ink was applied consistently throughout. Due to greater ink spraying, the letters were thicker than usual. The letters showed the application of a quicker printing method.

## 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 [1, 13]. 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 [14]. 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 [15, 16]. 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 [17]. Secondly, the text on Banknotes and Checks is printed using a specialized printing technique [18]. 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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