



EXAMINATION AND IDENTIFICATION OF DIGITAL PHOTOCOPIES AND LASER PRINTOUTS

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Abstract: The rapid increase in the use and availability of colored photocopiers and printers has made them an efficient tool for manipulating or duplicating genuine documents. Such instruments provide good resolution, high output of multiple copies with automatic feed and sorting facilities, which leads to the abuse of colored photocopies and printouts in a safer and sophisticated manner. Examining these duplicate documents always imposes challenges for the experts as they appear as good as genuine documents. Also, because of the similarity in the working principle of digital photocopiers and laserjet printers, the documents produced by such techniques give a similar appearance. This paper aims to enlist some physical characteristics that can significantly differentiate between the colored digital photocopy and colored laserjet printout, which can help a document expert determine forgery done using such techniques.

Keywords: photocopy, laser, printout, digital, document, variations

I. INTRODUCTION

All documents have content that can be forged by antisocial elements to fulfill their purpose. With evolving digital technology, one can easily alter any document's content or reproduce the whole document [1]. Easy access to photocopiers and printouts made it possible to use security documents in activities such as counterfeit banknotes [2], counterfeit passport, ransom letters, terrorism, etc. The introduction of colored digital photocopiers and color printers, which provide good resolution and a document that looks similar to the original document, proved to be a boon to people who use these technologies for criminal purposes.

Thus, document examiners face various questions, such as whether the given document is original or reproduced. What kind of reproduction is done: photocopy or printout? The yellow dot patterns printed by color laser printers (nearly invisible to the unaided human eye) can be used for printer identification [3]. The distinctive dot pattern is related to the serial number of a particular laser printer or photocopier [4,5]. The problem may arise to distinguish between laser printed and photocopied documents as they are very similar in their operation mode [6,7].

Here in this study, examining colored digital photocopied documents and colored laser printouts of documents is carried out to determine any significant difference between them based on their physical and instrumental analysis.

II. RESEARCH METHODOLOGY

Sample Procurement :

In total, 30 photocopied and laser printouts were collected from 10 original security documents such as certificates, mark sheets, and letterheads for conducting the study. The samples include colored photocopies and colored laser printouts of 10 original documents. Black and white digital photocopies and black and white laser printouts were also obtained to examine the significant changes. All Xerox and printouts were obtained from a canon machine. The samples' overall appearance, UV features, watermark, clarity of text and background, micro printing, and the document's dimension are some of the parameters that were examined.

The study's main focus was to identify features that can significantly distinguish between a photocopy and a Xerox. Also, a feature like tracking dots (small yellow dots), which are distributed all over the page and forms a particular pattern, were examined during this study. These dots' dimension differs from printer to printer, and these can be seen only in the documents that are printed by a laser printer. Thus, these dots link a printed document and a printer.

Analysis :

The analysis was done by comparing digital photocopies and laser printouts with their respective original documents, based on different parameters and security features, including:

- a) Dimensions of the document
- b) Presence of watermark
- c) Presence of security features
- d) The appearance of the background
- e) The sharpness of the seal
- f) Clarity of the background writings
- g) Color of the document
- h) Microprinting
- i) Margin design
- j) Perforations along the side of the document
- k) Color of the goldenseal and sharpness of its edges
- l) Dimensions of tracking dots
- m) Blackening of paper

The Quantitative interpretation of the data was performed based on statistical parameters like correlation, chi-square value, and p-value. The significance of the results was checked at $\alpha=0.05$ and 0.01 to determine the effectiveness of various parameters and security features in distinguishing between the original documents, photocopied documents, and computer printouts.

Materials and Instrument used:

- a) Scale
- b) Stereomicroscope
- c) VSC 40

Each color photocopy and color printout were compared with their respective original document. Stereomicroscope was used to observe the minute characteristics of the color photocopy and color printout. It was observed that there was deterioration in the quality of printed matter e.g., Edges of the characters, clarity of the seal, micro printing, margin design, etc.

It is understood that security features such as watermark and UV florescence (fig.4 and 5) will not be seen in any of the reproduced documents.

The Quantitative interpretation of some characteristics was performed based on statistical parameters like correlation, chi-square value, and p-value. The significance of the results as checked at $\alpha=0.05$ and 0.01 , to determine the chosen characteristics' effectiveness in identifying colored digital photocopy and colored laser printouts.



Figure 1. Margin design and microprinting in the original document

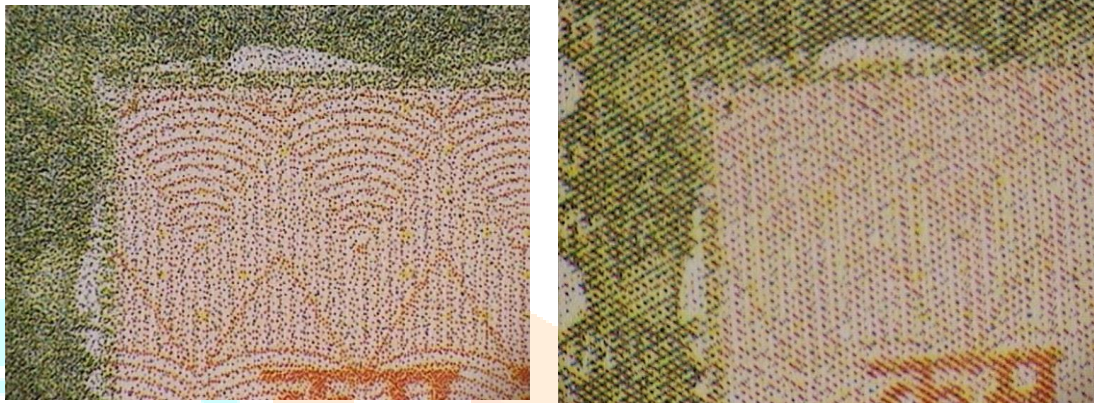


Figure 2. Margin design and microprinting are seen in the color photocopied document (left) and color laser printout (right). Microprinting is somehow visible in the photocopied document, but in the color printout, the microprinting appears just like some pattern of lines.

One can observe that the quality of margin design, micro printing (fig.2), and background design (fig.3) shows more deterioration in the color printout than the color photocopied document. In color photocopied document, the images and writings appear as a matrix of various small dots.

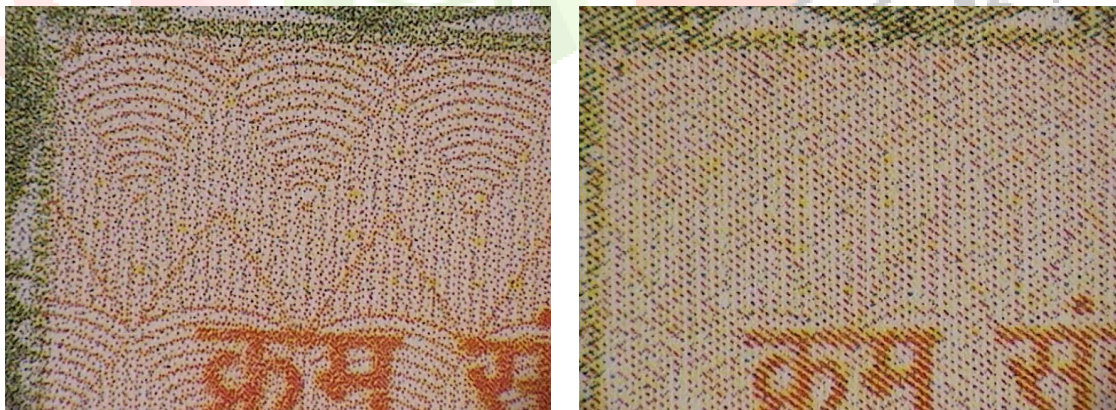


Figure 3. The difference in background design and writings between color photocopied document (left) and color printout (right). Writings appear proper with a matrix of dots on the left and appear as striations in the color printout.

प्राप्तक MARKS OBTAINED			
लि. TH	पि/अं.मू. PR/IA	योग TOTAL	योग शब्दों में TOTAL IN WORDS
088	XXX	088	EIGHTY EIGHT
079	XXX	079	SEVENTY NINE
055	018	073	SEVENTY THREE
045	026	071	SEVENTY ONE

Figure 4. UV features in the original document.

प्राप्तक MARKS OBTAINED				
सUBJECT	लि. TH	पि/अं.मू. PR/IA	योग TOTAL	योग शब्दों में TOTAL IN WORDS
COMM.	088	XXX	088	EIGHTY EIGHT
COURSE-A	079	XXX	079	SEVENTY NINE
ATICS	055	018	073	SEVENTY THREE
E	045	026	071	SEVENTY ONE
INTERNAL	018			
S-TH.EXT	008			
SCIENCE	068	019	087	EIGHTY SEVEN

Figure 5. Absence of UV features in color photocopied (left) document and color printout (right)

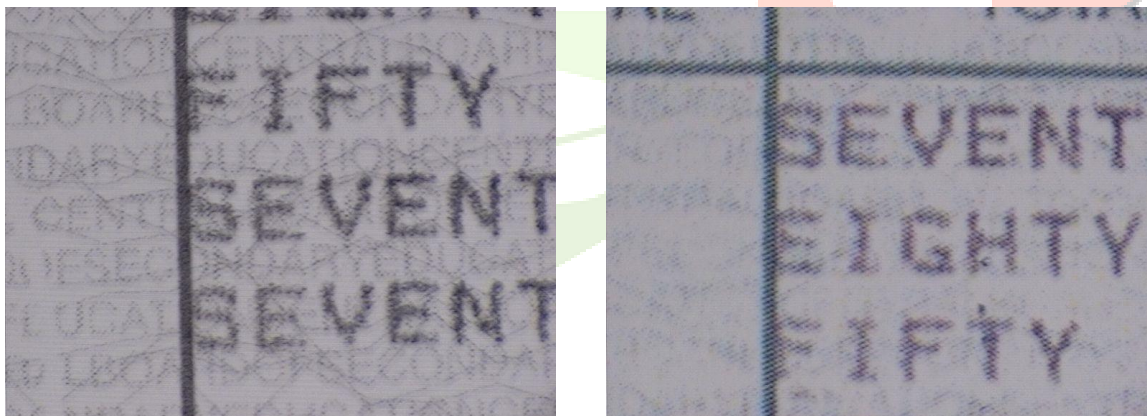


Figure 6. A comparison of Background appearance and appearance of text in colored digital photocopy (left) and laser printout (right). In laser printout, the background may become slightly visible to absent.

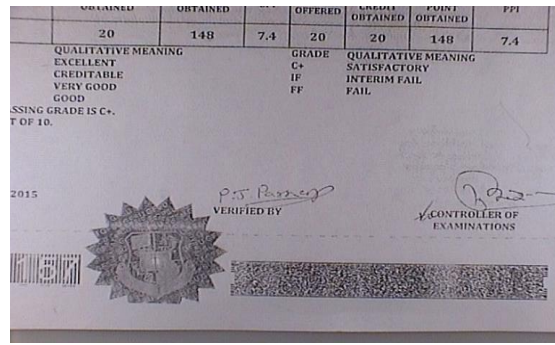
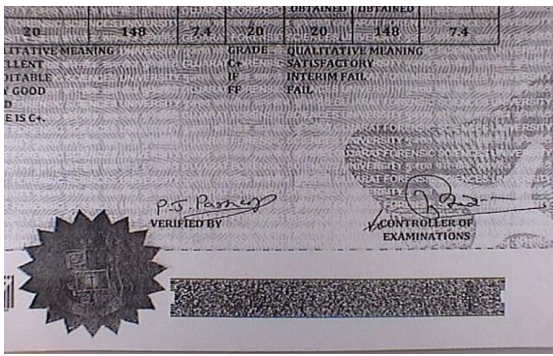


Figure 7. The appearance of seal, background, And blackening of paper in black and white digital photocopied (Left) and laser printout (right). The intensity of black toner is very light in laser printout, and thus, one can see that the background writings which can be seen in photocopy are entirely absent in laser printout.

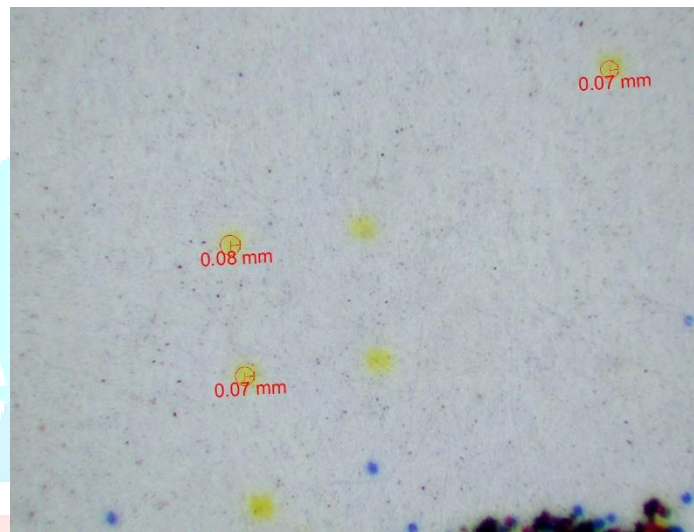


Figure 8. The dimension of Tracking dots in samples taken from canon printer was found to be 0.07 ± 0.01

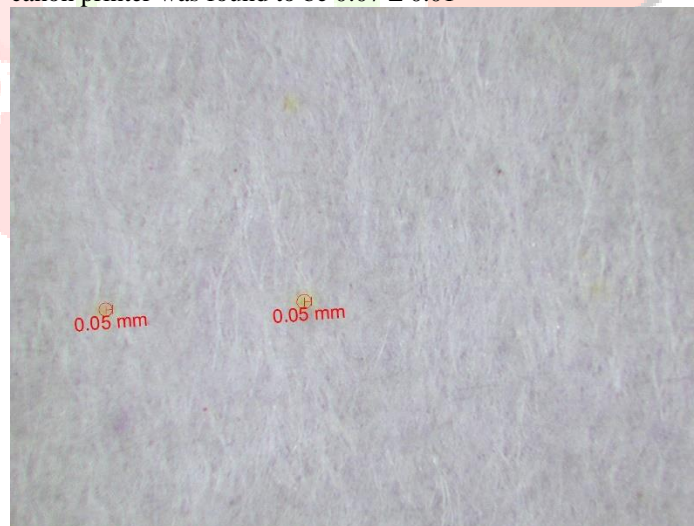


Figure 9. The dimension of tracking dots in hp LaserJet printer comes out to be 0.05, which can vary till ± 0.01

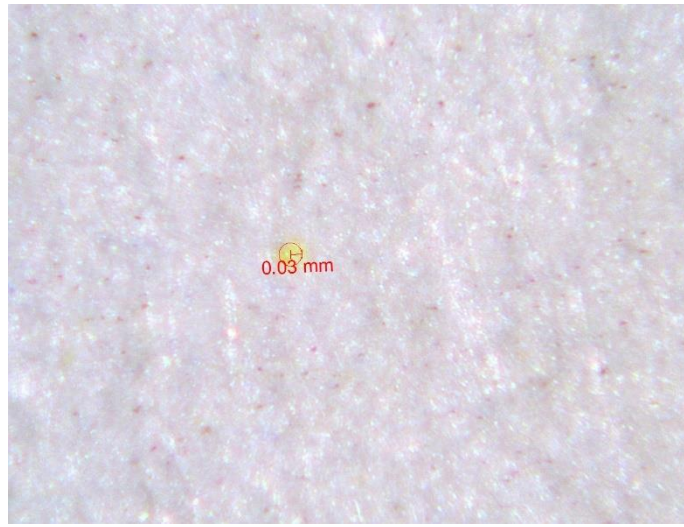


Figure 10. The dimension of tracking dots in komiko printer varies ranges from 0.03 ± 0.01

III. RESULTS AND DISCUSSIONS

Through the study and examination of colored digital photocopies and colored laser printout samples of the document, it was observed that these types of documents vary from each other, and some features can be used to differentiate between a color digital photocopy and a color laser printout.

One can also easily distinguish between an original document and a colored photocopy or colored printout by looking for security features such as watermarks and UV features like UV fluorescence and optical fibers.

In this study, 30 photocopied and laser printouts were collected from 10 original security documents and examined for characteristics such as certificates, mark sheets, and letterheads. The samples include colored photocopies and colored laser printouts of 10 original documents. Black and white digital photocopies and black and white laser printouts were also obtained to examine the significant changes. The reliability of the characters/ features which can be used to determine the origin of a reproduced colored document (whether the submitted document is a colored photocopy or printout) was checked at 0.05 and 0.01.

The examination of the photocopied documents and laser printouts revealed that features such as micro printing, the appearance of margin design, the appearance of written or printed text, and clarity of the background could be relied upon to identify whether the given document is photocopied or printed material.

In the case of black and white digital photocopy and laser printout, one can also rely upon the characteristics mentioned above and the blackening of paper. In black and white digital photocopy, one can observe a high level of blackening on the paper, and improper toner deposition. In contrast, in laser printout, toner deposition will be even and blackening will be less.

Table : 3.1 Descriptive stats for colored digital photocopy						
Characteristics	Correlation	Null hypothesis (H ₀)	Alternate hypothesis (H ₁)	chi sq. value	p value	Conclusion
Background	0.98	Background does not show variation	Background shows variation	1.090	0.579	Null hypothesis is accepted
Seal	0.99	Seal does not show variation	Seal shows variation	1.111	0.573	Null hypothesis is accepted
Watermark	-1	Presence of watermark does not show variation	Presence of watermark shows variation	7.777	0.005	Null hypothesis is rejected
Background writings	0.88	Background writings does not show variation	Background writings shows variation	2.4	0.301	Null hypothesis is accepted
Color of the document	-1	Color of the document does not show variation	Color of the document shows variation	7.77	0.005	Null hypothesis is rejected
Microprinting	-0.85	Micro printing does not show variation	Micro printing shows variation	8	0.018	Null hypothesis is rejected
Security features	-1	Security features does not show variation	Security features shows variation	5.6	0.017	Null hypothesis is rejected
Latent Image	1	Latent image does not show variation	Latent image shows variation	0	1	Null hypothesis is accepted
Margin design	0.91	Margin design does not show variation	Margin design shows variation	1.333	0.513	Null hypothesis is accepted
Punching holes	1	Latent image does not show variation	Latent image shows variation	0	1	Null hypothesis is accepted
Color of golden seal	0.68	Color of the golden seal does not show variation	Color of the golden seal shows variation	4	0.135	Null hypothesis is accepted
Edges of golden seal	0.68	Edges of the golden seal does not show variation	Edges of the golden seal shows variation	4	0.135	Null hypothesis is accepted

Table : 3.2 Descriptive stats for colored laser printout						
Characteristics	Correlation	Null hypothesis (H ₀)	Alternate hypothesis (H ₁)	chi sq. value	p value	Conclusion
Background	-0.84	Background does not show variation	Background shows variation	7.904	0.019	Null hypothesis is rejected
Seal	0.99	Seal does not show variation	Seal shows variation	1.111	0.573	Null hypothesis is accepted
Watermark	-1	Presence of watermark does not show variation	Presence of watermark shows variation	7.777	0.005	Null hypothesis is rejected
Background writings	0.88	Background writings does not show variation	Background writings shows variation	11.333	0.003	Null hypothesis is rejected
Color of the document	-1	Color of the document does not show variation	Color of the document shows variation	14	0.0001	Null hypothesis is rejected
Microprinting	-1	Micro printing does not show variation	Micro printing shows variation	5.6	0.017	Null hypothesis is rejected
Security features	-1	Security features does not show variation	Security features shows variation	5.6	0.017	Null hypothesis is rejected
Latent Image	0.68	Latent image does not show variation	Latent image shows variation	4	0.135	Null hypothesis is accepted
Margin design	0.68	Margin design does not show variation	Margin design shows variation	0.684	0.684	Null hypothesis is accepted
Punching holes	1	Latent image does not show variation	Latent image shows variation	1.4	0.236	Null hypothesis is accepted
Color of golden seal	0.68	Color of the golden seal does not show variation	Color of the golden seal shows variation	4	0.135	Null hypothesis is accepted
Edges of golden seal	0.68	Edges of the golden seal does not show variation	Edges of the golden seal shows variation	4	0.135	Null hypothesis is accepted

Table 3.3 : Descriptive stats for black and white digital photocopy						
Characteristics	Correlation	Null hypothesis (H ₀)	Alternate hypothesis (H ₁)	chi sq. value	p value	Conclusion
Background	-1	Background does not show variation	Background shows variation	6	0.014	Null hypothesis is rejected
Seal	1	Seal does not show variation	Seal shows variation	1.2	0.273	Null hypothesis is accepted
Watermark	-1	Watermark does not show variation	Watermark shows variation	6	0.014	Null hypothesis is rejected
Background writings	-1	Background writings does not show variation	Background writings shows variation	6	0.014	Null hypothesis is rejected
Color of the document	-1	Color of the document does not show variation	Color of the document shows variation	6	0.014	Null hypothesis is rejected
Microprinting	-1	Micro printing does not show variation	Micro printing shows variation	3	0.083	Null hypothesis is accepted
Security features	-1	Security features does not show variation	Security features shows variation	3	0.083	Null hypothesis is accepted
Margin design	0.5	Margin design does not show variation	Margin design shows variation	2	0.367	Null hypothesis is accepted
Punching holes	1	Latent image does not show variation	Latent image shows variation	0	1	Null hypothesis is accepted
Color of golden seal	0.5	Color of the golden seal does not show variation	Color of the golden seal shows variation	2	0.367	Null hypothesis is accepted
Edges of golden seal	0.5	Edges of the golden seal does not show variation	Edges of the golden seal shows variation	2	0.367	Null hypothesis is accepted
Photograph	0.5	Photograph does not show variation	Photograph shows variation	2	0.367	Null hypothesis is accepted
Blackening of paper	1	Blackening of paper does not show variation	Blackening of paper shows variation	1.2	0.273	Null hypothesis is accepted

Characteristics	Correlation	Null hypothesis (H ₀)	Alternate hypothesis (H ₁)	chi sq. value	p value	Conclusion
Background	-0.866	Background does not show variation	Background shows variation	6	0.049	Null hypothesis is rejected
Seal	-1	Seal does not show variation	Seal shows variation	3	0.083	Null hypothesis is accepted
Watermark	-1	Watermark does not show variation	Watermark shows variation	6	0.014	Null hypothesis is rejected
Background writings	-0.866	Background writings does not show variation	Background writings shows variation	6	0.049	Null hypothesis is rejected
Color of the document	-1	Color of the document does not show variation	Color of the document shows variation	6	0.014	Null hypothesis is rejected
Microprinting	-1	Micro printing does not show variation	Micro printing shows variation	3	0.083	Null hypothesis is accepted
Security features	-1	Security features does not show variation	Security features shows variation	3	0.083	Null hypothesis is accepted
Margin design	0.5	Margin design does not show variation	Margin design shows variation	2	0.367	Null hypothesis is accepted
Punching holes	1	Latent image does not show variation	Latent image shows variation	0	1	Null hypothesis is accepted
Color of golden seal	0.5	Color of the golden seal does not show variation	Color of the golden seal shows variation	2	0.367	Null hypothesis is accepted
Edges of golden seal	0.5	Edges of the golden seal does not show variation	Edges of the golden seal shows variation	2	0.367	Null hypothesis is accepted
Photograph	1	Photograph does not show variation	Photograph shows variation	0	1	Null hypothesis is accepted
Blackening of paper	1	Blackening of paper does not show variation	Blackening of paper shows variation	1.2	0.273	Null hypothesis is accepted

5. CONCLUSION

After examining digital photocopied documents and laser printouts samples of different documents, we have concluded that if the examiner follows the proper well-designed methodology, he will be able to successfully determine the origin of the produced documents, i.e., whether it is a digital photocopy or laser printout.

Although every reproduced digital photocopy and laser printout may appear similar to the layman at first glance, one can notice differences if examined closely.

In terms of quality and clarity, the colored digital photocopy shows much more sharpness and clarity than the laser printout. Even the written or printed text shows a variation in both types of documents. But the most significant changes that can be seen are micro printing, margin design, the appearance of background, and clarity of the text.

In the case of colored digital photocopy, microprinting is visible, and one can vaguely identify the text written. Still, in the case of laser printout, it appears like small oblique bars, and thus one cannot see microprinting in the case of colored laser printout. Margin design appears evident in the colored digital printout compared to laser printout, in which the toner particles do not seem to connect properly to form the proper contours of the design.

The same is the case with the appearance of background in the text (as shown in fig. 3). Although the background and text appear granular in colored photocopy, it is much clearer and sharper than that of a laser printout.

All these features can also be observed in black and white digital photocopy and laser printout. Still, the other thing that can be seen is the degree of blackening of paper, which is more significant in the case of digital photocopy and less to negligible in laser printout. Also, tracking dots will be seen under UV, only in the documents produced through laser mechanism i.e., in laser printouts. The dimension of these dots varies in different printers of different manufacturers, i.e., each printer manufacturer will have a specific size of the dots.

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