

Forensic Colour Differentiation of Ink Strokes using Image Processing Techniques

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ABSTRACT: The use of ballpoint pen inks has become very common in the forgeries of documents related to financial transactions, wills, agreements, contracts, and many other documents. Most of the conventional methods of detection are destructive in nature. Image processing technique is very useful in this aspect. It is fast, reliable and non-destructive in nature. It can be reliably used for the examination of ballpoint pen inks. In this study, ballpoint pen ink samples have been analysed with the help of two image processing software, including Adobe Photoshop CC 2014 and Picasa 3 in order to differentiate similar colour inks of red, blue and black ballpoint pens. These techniques have allowed the separation of ballpoint pen inks.

Keywords: forensic document examination, questioned documents, image processing, ballpoint pen, overlapped inks

Introduction

Forensic analysis of writing inks has undergone stern change. The determination of chemical composition of an ink leads to identification of the ink type. The affirmation of similarity/ dissimilarity of strokes and composition of ball point pen inks become significant in case the question emanates, whether two writings have been executed with the same pen ink or with different ink. The important cases related to ink analysis involve forged cheques, wills, agreements, contracts, and other financial documents.

Forgery has become much easier task for forgers with the advent and development of image processing techniques. A number of approaches have been used to make alterations in the composed records, such as interlineations, cancelation, addition, and obliterations. Also, digital technology provides advanced applications which prove their usefulness in the determination of alterations and authentication of documents. Various non-destructive methods such as Color Deconvolution Algorithm in image processing [1] and UV-visible absorption spectra [2] have been used to differentiate writing inks. Image processing is one of the most successfully used techniques for the differentiation and comparison of ink components, which provides effective and quick results [3]. Adobe Photoshop, being a non-destructive and fast method has been used to differentiate blue gel pen inks [4]. The problems related to identification of printing technology in case of image

processing application have been projected as a challenge [5]. Research has been conducted to separate different inks using image processing techniques [6]. Katrin and Koppen (2001) presented a computer based study of handwritten documents using image processing and prototype detection methods [7]. Mushtaq and Rahnamayan (2015) studied image processing techniques in order to differentiate variant colours [8].

The review of literature elaborates accomplishments made in the previous researches, which has encouraged the establishment of a new approach for the analysis of ink. Thus, the present research encompasses differentiation of similar colour inks of red, blue and black ballpoint pens using two image processing software, namely Adobe Photoshop CC 2014 and Picasa 3 image processing software.

Material and methods

The study was divided into two parts for examining the differentiation of ballpoint inks of similar brand and colour but of different models.

Sample collection

Fifteen ballpoint pens of five different models with three different colours (black, red and blue) were selected for the study and marked by their acronyms and further used for the sample preparation as tabulated in Table 1.

Table 1: Different models of ballpoint pens marked with their acronyms

Serial Number	Color of pens	Description	Acronyms
1	Black	Universal Rainbow	UR
2	Black	Reynold Liquiguide	RL
3	Black	Cello Ammeter	CM
4	Black	Huser Germany	HG
5	Black	Reynold Champ	RC
6	Red	Montex Sury	MS
7	Red	Cello Techno Tip	CTT
8	Red	Flair Sharp Point	FSP
9	Red	Goldex Klassy	GK
10	Red	Pentex Stylo	PS
11	Blue	Win Zest	WZ
12	Blue	Fino Dx	FD
13	Blue	Montex Tricon	MT
14	Blue	Reynolds Fine Curbure	RFC
15	Blue	Pentex Stylo	PS

Sample preparation

All pens were used to prepare experimental samples on white paper of A4 size. Samples were prepared in the manner that writings of two similar ballpoint pen inks overlapped each other. Three words, that is, "For Experimental Purpose" were written using blue, red and black coloured ballpoint pens. These were further overwritten using the same colored ball point pens respectively.

To verify the results, three control samples were prepared using the same ballpoint pens. Control samples comprising of ‘over’ and ‘under’ written test phrase were executed by the same pens, thus resulting in a total number of 63 samples. All the samples were scanned and converted into digital images using a scanner (HP SHNGC-1302-00). The scanned images were further stored in JPEG format.

Examination of scanned ink samples

To analyse the prepared samples, three standard methods were developed using Adobe Photoshop CC 2014 and Picasa 3 image processing softwares. Red, Green and Blue (RGB) colours are known as primary colours. The colours are described on the basis of three elements, that is, Hue, Value, and Saturation. Red, blue and black colours have difference in hue, value, and saturation. Thus, three standard methods were generated in order to differentiate these colors, which employed a set of tools comprising Picasa 3 and Adobe Photoshop image processing softwares. Using standard method I (Table 2), strokes executed by black ballpoint pens only could be differentiated. The need to analyse red and blue ballpoint pen strokes led to the development of standard method II (Table 3) and III (Table 4), comprising of different tools which proved to be effective enough for distinguishing red and blue pen strokes.

Table 2: Picasa 3 and Adobe Photoshop tools

Serial number	Picasa 3 and Adobe Photoshop CC 2014 Image Processing Softwares
1	The Filter B/W from the third window of Picasa tool was used to bring the image at gray-scale level.
2	To enhance the color of inks, Sharpen tool was used at the low level from the same window.
3	I’m feeling lucky tool was selected to enhance the brightness of the image. After selecting fill light tool at the medium level, the image was highlighted.
4	From the Orton-ish tool, bloom, brightness and fade options were selected at high, medium and low levels respectively.
5	Fill light tool at high level was used to reduce the color intensity of the ink.
6	I’m feeling lucky tool was applied again on the image from the same window.
7	Again fill light tool was used at medium level, decreasing the temperature at low level from the tuning section.
8	Cinemoscope and I’m feeling lucky tool were used one after the other to change the background appearance, color intensity, and dullness respectively.
9	Sepia tool was applied on the image to alter the strength of the color followed by change in saturation level at medium.
10	Adobe Photoshop was opened and ‘exposure command’ was used at custom level to process all of the previously saved images.
11	The level of exposure, offset and gamma correction was set at 0.22, 0.826, and 0.91 respectively.

Table 3: Picasa 3 tools

Serial number	Picasa 3 Image Processing Software
1	The scanned image was opened in Picasa 3 image processing software and the cross process tool was used to reduce the intensity of colors.
2	The cinemoscope tool was applied to decrease the background sharpness. The bloom, brightness and fade from Orton-ish section were used at low, high and again low levels respectively
3	To increase the intensity of the inks, I'm feeling lucky tool was used and thus, the prominent difference between the colors of inks was observed.
4	Then, the shadow tool was used at high level from the tuning section. The blue color was selected from tint tool to convert the red color into bluish shade.

Table 4: Picasa 3 and Adobe Photoshop tool

Serial number	Picasa 3 and Adobe Photoshop Image Processing Softwares
1	To compare the unlikeness between inks, auto contrast tool was initially used on saved images.
2	After that, fill light tool was used at high level which reduced the intensity of colors and thus resulted in variability of inks.
3	I'm feeling lucky was the next tool, which was used to enhance the intensity of the color of inks. The color intensity of one of the inks then became prominent.
4	Cinemoscope tool was used without selecting letter box. To enhance the results, I'm feeling lucky tool was used again.
5	In Adobe Photoshop , using Adjustment (Black and White) command, which set the value of yellow, green, cyan, blue, magenta at 60, 300, 300, 27, -200 respectively.

Results

All the digital ink samples have been analysed using Picasa 3 and Adobe Photoshop image processing softwares. Remarkable separation of ballpoint pen inks has been observed in each of underlying and overlying words in 86% of the samples (Table 5). The separation of inks was observed with the reduction in the colour intensity of one of the inks,

while the other inks increased in their intensity (Figures 1-3). In order to cross check the occurrence of above said phenomenon, the control samples were subjected to the same visual analysis. However, the control samples did not render any such change in the intensity of inks as exhibited by the prepared samples (Figure 4-6). The results thus obtained from the examination of prepared samples using image processing softwares have been verified.

Table 5: Number of Red, Black, and Blue pens in conclusive, inconclusive, and negative results

Serial no.	Color of ballpoint pen ink	Conclusive results	Negative results	Total no. of pens
1	Black	18	2	20
2	Red	17	3	20
3	Blue	17	3	20
4	Total	52	8	60

Discussion

The pattern of tools used in Standard method I have not shown promising results when applied on red and blue ballpoint pens. Standard method II has been applicable only to red ballpoint pens and Standard method III to blue ballpoint pens only. As Red, Green and Blue (RGB) are known as the primary colours, other colours are created using different combinations of these three primary colours. The colours are described on the basis of three elements such as Hue, Value, and Saturation which differed in respective red, blue and black colors. Thus, three different standard methods have been created for different colors.

The separation of 47 out of 63 ballpoint pen inks was achieved by employing Adobe Photoshop and Picasa image processing softwares. Results obtained using image processing methods have shown reduction in intensity of one of the ballpoint pen inks as compared to the other inks using Picasa 3 and Adobe Photoshop softwares. The study demonstrates the fact that a change in the intensity of identical colours of ballpoint pen inks can prove to be a valuable aspect in the examination of inks in questioned documents. Effective and encouraging results have thus been obtained on the basis of visual observation of reduction/ escalation of colour intensity of the overlying and underlying inks. The results of the study shows that the image processing software used here served as an easy, reliable and non-destructive

technique for performing differentiation of black, red and blue ballpoint inks.
(A) (B)



Figure 1: (A) The original scanned document of blue ball point ink strokes; (B) The separation of the ink observed by change in color intensities of two blue ball point ink strokes.

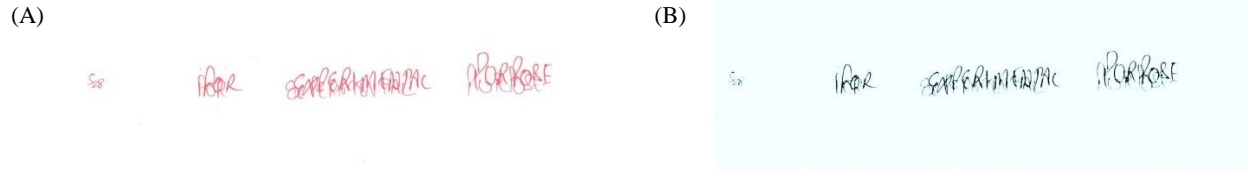


Figure 2: (A) The original scanned document of red ball point ink stroke; (B) The separation of the ink observed by change in color intensities of two red ball point ink strokes.



Figure 3: (A) The original scanned document of black ball point ink strokes; (B) The separation of the ink observed by change in color intensities of two black ball point ink strokes.



Figure 4: (A) The original control scanned document of blue ball point ink strokes; (B) No separation of the ink observed by change in color intensities of two same blue ball point ink strokes.

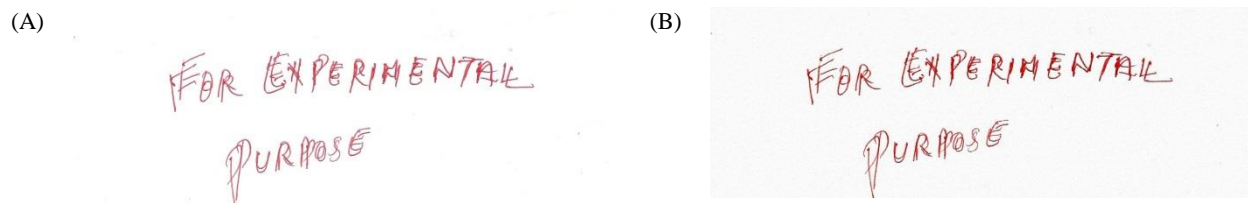


Figure 5: (A) The original control scanned document of red ball point ink strokes; (B) No separation of the ink observed by change in color intensities of two same red ball point ink strokes.

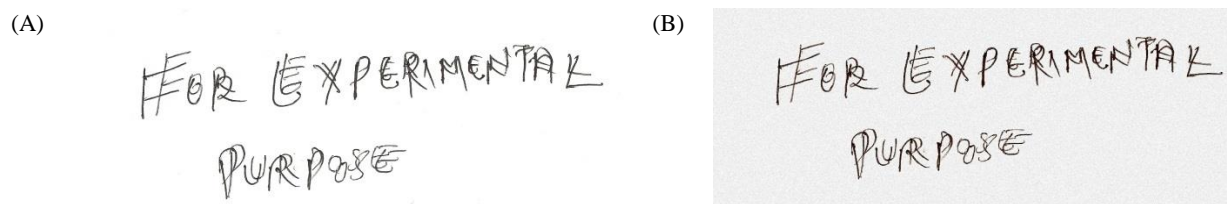


Figure 6: (A) The original control scanned document of black ball point ink strokes; (B) No separation of the ink observed by change in color intensities of two same black ball point ink strokes.

Conclusion

Forensic document examiners usually encounter cases where detection of manipulations in the documents with identical ballpoint pen inks becomes imperative. Image processing software could be utilised in such cases. The study has been conducted with an aim to differentiate the writings executed by similar colored ballpoint pen inks. The results illustrate the significance of image processing softwares. These softwares have been found to be reliable, easy to use and non-destructive in nature, which can be used for the differentiation of black, red, and blue ballpoint inks.

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