ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2521-5051 (Print)
ISSN: 2521-506X (Online)
CODEN: ASMCCQ

Acta Scientifica Malaysia (ASM)

DOI: http://doi.org/10.26480/asm.02.2022.38.42

RESEARCH ARTICLE

STUDY OF CHRONOLOGICAL ORDER IN INTERSECTING PRINTED AND PEN STROKES WITH THE HELP OF CHROMATICITY DIAGRAM

Roshan Giri[a], Shanker Prasad Chimouriya[b] and Bal Ram Ghimire[c*]

[a]National Forensic Science Laboratory, Khumaltar, Lalitpur, Nepal
[b]Department of Natural Sciences (Physics), Kathmandu University, Kavre, Nepal
[c]Central Department of Physics, Tribhuvan University, Kirtipur, Kathmandu, Nepal
**Corresponding Author Email: balramghimire@gmail.com*

ARTICLE DETAILS

Article History:

Received 05 May 2022
Accepted 10 June 2022
Available online 14 June 2022

ABSTRACT

Writing cross stroke examination is one of the difficult and challenging problem in forensic document examination. In this work, we tried to find sequence of order in crossing printed and pen strokes. The study mainly deals with application of chromaticity diagram generated by Video Spectral Comparator (VSC)-6000. Chromaticity co-ordinates are generated from three different points of first, second and cross strokes. When two strokes cross each other, then surface on point of intersection corresponds to second stroke. So, we have started this work with the assumption that chromaticity co-ordinate (x,y) of the crossing stroke should be similar to that of second stroke. We perform our experiment in both homogeneous and heterogeneous crossing strokes. We repeat the same experiment five times by preparing different samples each time to establish more valid conclusion but we get positive and conclusive results only in the case of heterogeneous crossing strokes where printed stroke is above the pen strokes.

KEYWORDS

document examination, non-destructive, homogemneous, heterogeneous, strokes, tristimulus values

1. INTRODUCTION

Main aim of document examiner is to find fact and truth behind the document by applying appropriate scientific tools and methodologies. During this work of questioned document examination, forensic document examiners often face many challenging problems. One of these problems is determination of chronological order of sequence of crossing strokes which is not new problem in the field of document examination. It is very important to determine which stroke is executed later in crossing strokes because it helps to establish authenticity of documment (Osborn, 1929). Also, it plays vital role in criminal justice system.

For determining order of sequence in crossing strokes, many works have been done. B. A. Vaid e*t al.* (Vaid et al., 2011) studied for determination of sequence of strokes through reflection spectra by using Video Spectral Comparator-2000HR. They successfully established chronological order in the case of heterogeneous crossing strokes for ballpoint pens whereas they failed in homogeneous crossing strokes and strokes from gel pen. Similarly, M. Mann et al. carried out this work by the application of confocal microscope (Mann et al., 2019) and Docubox Dragon (Mann et al., 2013). Nikon N1 confocal microscope is able to analyze sequence of order from homogeneous inks in cross stroke through three-dimensional images even in low pen pressure. G. S. Spagnolo described about potentiality of 3D laser profilometry for determining sequence of homogeneous crossing lines (Spagnolo, 2006). Here, 3D micro-topography is obtaainned from conoscopy holography. And this method is found very helpful to recover correct stroke sequence in a handwritten script. Also, it is discussed that this method is able to analyze pressure variation during writing. A. K. Gupta et al. (Gupta et al., 1987) discussed about use of photography with glossy paper treated with Pyridine to lift for establishing order of sequence in crossing strokes. Also, R. Kaur et al. did work for establishing chronological order in crossing strokes of intersecting printed strokes and writing pens. Experiment was done on laser printer (black, blue, red and green) and typewriter (black) for printed stroke whereas for pen strokes ballpoint pens, gel pen and fountain pens of different color ink including black, blue, red and green were used. They analyzed absorption spectra generated by VSC-2000HR. They obtained inconclusive results (Kaur et al., 2013).

In this work, we have tried to use chromaticity diagram for determining order of sequence in crossing strokes by writing pens and printed strokes. Many experiments and methodologies are used to establish chronological order in crossing strokes but we do not find use of concept of chromaticity diagram. So, we decided to carry out this experiment. Since, this is one of the non-destructive methods, it is better to carry out this work by other forensic document examiners to establish more valid conclusion.

2. THEORY

Human eye can see only visible light which is small fraction of electromagnetic radiation wavelength ranging from 380 nm (violet) to 780 nm (deep red). Cones of human eye are responsible for color vision. Cones of human eye are divided into short-wavelength sensitive cone (S-cone), middle-wavelength sensitive cone (M-cone) and long-wavelength sensitive cone (L-cone) which are responsible for vision of blue, green and red respectively (Bieske *et al.,* 2007). So, it is clear that human eye converts visible light into three stimuli X, Y and Z : one cone for red (X), one cone for green (Y) and one cone for blue (Z). These three values X, Y and Z are called tristimulus values and represents the amount of red, green and blue needed to form a particular color. These tristimulus values X, Y, Z generate three-dimensional color space which is very complex (Suresh & Jain, 2013). So, these three stimuli should be normalized and normalization is done by following operations.

Quick Response Code	Access this article online	
	Website: www.actascientificamalaysia.com	**DOI:** 10.26480/asm.02.2022.38.42

Cite The Article: Roshan Giri, Shanker Prasad Chimouriya and Bal Ram Ghimire (2022). Study of Chronological Order in Intersecting Printed and Pen Strokes with The Help of Chromaticity Diagram. *Acta Scientifica Malaysia, 6(2): 38-42.*

$$x = X/(X+Y+Z) \quad (1)$$

$$y = Y/(X+Y+Z) \quad (2)$$

$$z = Z/(X+Y+Z) \quad (3)$$

It is clear that value of 'z' is obtained from 'x' and 'y' by using very simple relation z = 1 – (x +y) since x + y + z = 1. Here, x, y and z are called trichromatic coefficient. Tristimulus values give absolute values whereas trichromatic coefficient gives relative values of red, green and blue to form a specific color (Suresh & Jain, 2013). Hence, by defining trichromatic coefficient, three-dimensional color space is reduced into two-dimensional (x,y) color space.

Every color has its own specific appearance depending upon three elements: hue, chroma and value. Hue simply refers to object's color – red, orange, green, blue etc. Chroma is the vividness or dullness of a color and value or lightness describes luminous intensity of a color i.e. its degree of lightness. Hue and saturation together form chromaticity. So, any color can be specifically characterized its brightness and chromaticity. Chromaticity diagram or CIE chromaticity diagram proposed by Commission International de I'Eclairage (1931) is an objective specification of the quality of color. It is a graph which shows all possible colors and each color is defined by a pair of numerical co-ordinate – the chromaticity co-ordinate (x,y). If two colors differ in chromaticity, they are represented by two different points in chromaticity diagram (CIE Techn. Report, 2006).

In writing process, very thin colored layer is made on the paper. In the crossing stroke of writing, one line is crossed over another line i.e. two very thin colored layers are one over another. This work is based on the fundamental assumption that chromaticity co-ordinate (x,y) of crossing stroke must match with that of second stroke since thin ink layer of second stroke is above the first stroke.

3. Materials and Method

For this study, we have chosen nine different types of pens of different colors including cello maxriter pen (black and blue), pilot pen (red and black), cello pointec pen (black and blue) and cello techno tip pen (red, black and blue) for writing stroke. Specially, we choose these pens since they are popular and frequently used in Nepal. Similarly, Canon LBP 3300 printer is used to produce black color printed strokes. We carried out this work on both homogeneous and heterogeneous crossing strokes i.e. crossing strokes from same and different colors respectively. Samples of crossing strokes are prepared by ourselves on white photocopy paper. In this work, we use Video Spectral Comparator (VSC)-6000 to generate chromaticity diagram.

3.1 Video Spectral Comparator (VSC)-6000

VSC is very useful tool in document examination which allows an examiner to analyze ink (Manal & Abd, 2014), reveal alteration in document (Panday et al., 2018) visualize hidden security features in currency (Pathak & Paul, 2019, Giri et al., 2021), passport (Gupta & Ravi, 2017, Gupta at al., 2016) etc., determine chronological of crossing strokes (Vaid et al., 2011, Kaur et al., 2013) enhance handwriting on charred documents (Moorthy & Narayanan, 2016) etc. that uses different light sources for examination of document. At first power of VSC is switch on and appropriate setting is done before working. The position of document to be checked is adjusted by viewing on the monitor. To get large sample size, the image is zoomed to maximum. After placing the document, chromaticity co-ordinates and diagram are generated from different three points of first stroke, second stroke and crossing stroke. Once the required diagram is obtained, then it is saved.

Here, chromaticity co-ordinates and diagrams are developed from the light of wavelength ranging from 400 nm to 1000 nm. Finally, chromaticity co-ordinates from first stroke, second stroke and crossing stroke are compared to come to conclusion with the help of chromaticity diagram.

Figure 1: Video Spectral Comparator (VSC)-6000

4. Results and Discussion

In this section, we have discussed in detail about the chromaticity diagram and different chromaticity co-ordinates generated by VSC-6000 for our samples of crossing strokes. To make more clear about obtained results, this section is further divided into two subsections.

4.1 Pen Stroke Over Printed Stroke

To prepare such samples, at first we get some prints on white color photocopy paper and then we write straight lines above the prints. As a result, we obtain crossing strokes in which pen stroke is over the printed stroke. We carried out our experiment on both homogeneous and heterogeneous crossing strokes. In all samples, we get negative results. It means this experiment is failed to establish chronological order of crossing stroke if pen stroke is after the printed stroke. Here, one of these results is discussed in detail with different chromaticity co-ordinates and chromaticity diagram.

In this sample, first stroke is black color printed stroke and over which second stroke is written by red cello techno tip pen. All different chromaticity co-ordinates obtained for this sample is shown in Table 1. Plot of these co-ordinates in chromaticity diagrams are shown in figure 2, figure 3 and figure 4. From these chromaticity diagrams, it is clear that chromaticity co-ordinates represented by +1, +2 and +3 of first stroke (black printed stroke) are close to each other and clustered. Same nature is shown by second stroke too. It is expected to cluster chromaticity co-ordinates of crossing strokes within that of second stroke by red cello techno tip pen. But we find negative result than our assumption. It means, chromaticity co-ordinates of crossing stroke completely do not match with that of second stroke which is made more clear from chromaticity diagrams represented by figure 2, figure 3 and figure 4.

Table 1: Different chromaticity co-ordinates where numbers 1, 2 and 3 for first black printed stroke by Canon LBP 3300 printer; numbers 4, 5 and 6 for second writing stroke by red cello techno tip pen; numbers 7, 8 and 9 for crossing stroke

Number	X	Y	Z	x	y	u	v	L*	a*	b*	u*	v*
1	0.122	0.119	0.136	0.324	0.316	0.211	0.308	41.1	2.0	-4.5	0.3	-5.9
2	0.142	0.135	0.16	0.325	0.309	0.215	0.306	43.5	4.4	-6.0	2.4	-8.4
3	0.16	0.161	0.171	0.326	0.327	0.208	0.313	47.1	-0.6	-2.2	-1.8	-2.6
4	0.636	0.488	0.397	0.418	0.321	0.278	0.32	75.3	36.3	10.5	66.1	6.4
5	0.593	0.448	0.403	0.411	0.31	0.278	0.315	72.8	37.5	5.3	64.2	-0.5
6	0.645	0.499	0.362	0.428	0.331	0.28	0.325	76.0	35.4	16.1	68.7	13.5
7	0.111	0.097	0.106	0.354	0.308	0.237	0.308	37.3	10.6	-2.8	12.8	-5.3
8	0.323	0.229	0.149	0.461	0.327	0.308	0.327	55.0	37.2	16.3	69.6	11.8
9	0.13	0.132	0.134	0.33	0.332	0.208	0.315	43.0	-0.7	-0.6	-1.3	-0.6

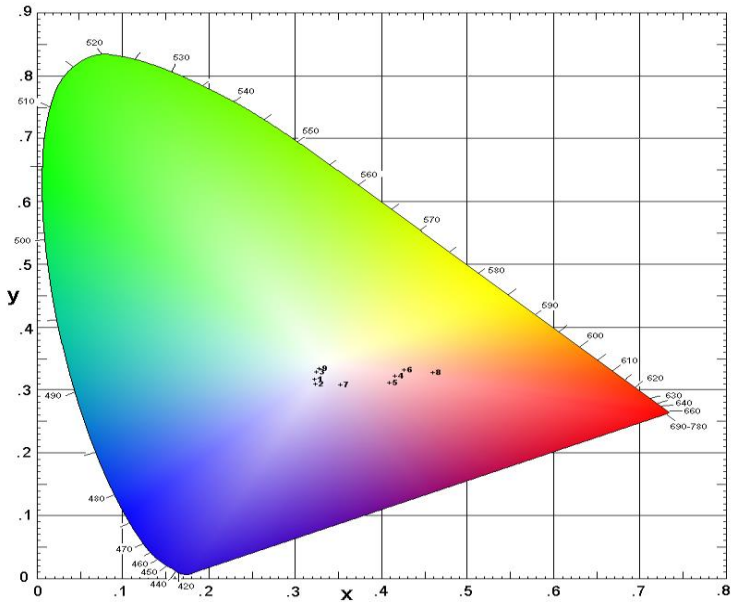

Figure 2: xy Chromaticity diagram generated by using Video Spectral Comparator (VSC)-6000 where +1, +2 and +3 represent for first black print stroke by Canon LBP 3300 printer; +4, +5 and +6 represent for second writing stroke by red cello techno tip pen; +7, +8 and +9 represent for crossing stroke

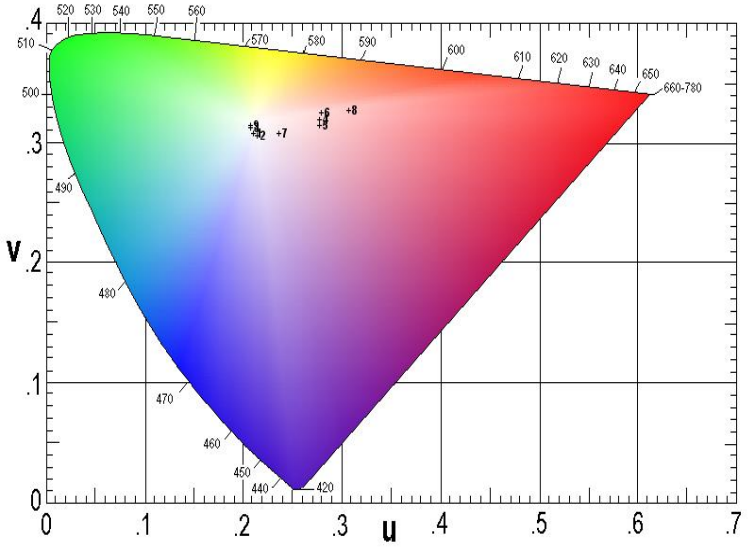

Figure 3: uv Chromaticity diagram generated by using Video Spectral Comparator (VSC)-6000 where +1, +2 and +3 represent for first black print stroke by Canon LBP 3300 printer; +4, +5 and +6 represent for second writing stroke by red cello techno tip pen; +7, +8 and +9 represent for crossing stroke

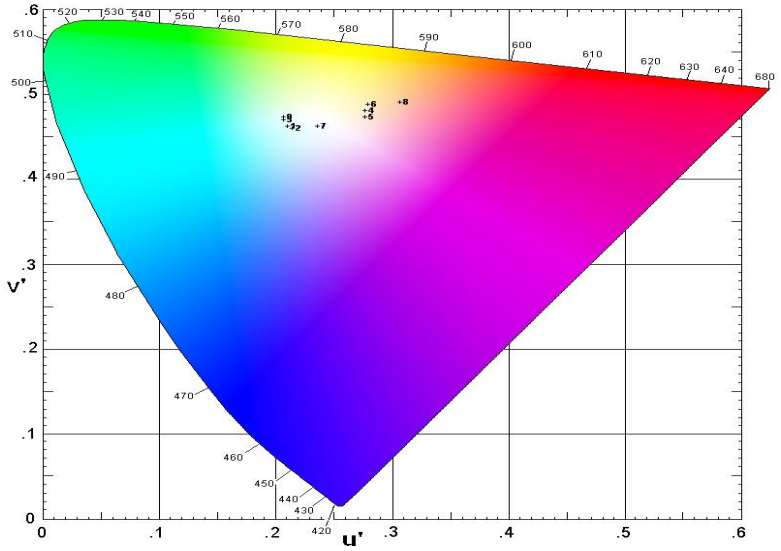

Figure 4: u'v' Chromaticity diagram generated by using Video Spectral Comparator (VSC)-6000 where +1, +2 and +3 represent for first black print stroke by Canon LBP 3300 printer; +4, +5 and +6 represent for second writing stroke by red cello techno tip pen; +7, +8 and +9 represent for crossing stroke

4.2 Printed Stroke Over Pen Stroke

To prepare samples of crossing strokes where printed stroke is above the pen stroke, we write straight line on white photocopy paper from different pens and then we get print from our printer. In this case also, we did experiment on both homogeneous and heterogeneous crossing strokes. For printed stroke, only black print stroke is used. After the experiment, negative result is obtained for homogeneous crossing strokes whereas positive result is obtained for heterogeneous crossing strokes.

When we write by our black color pens and over them print is done, then we get inconclusive and negative results to establish sequence of intersecting strokes. But if we write straight lines by our red and blue colors pen and then print is taken on them, we get positive results according to our assumption. It means it is possible to find order of sequence for heterogeneous crossing strokes if print stroke is over pens stroke by the application of chromaticity diagram. In this section, negative result is not discussed in detail but we have explained in detail about one positive result.

Here, first stroke is made from red cello techno tip pen and over which second stroke is executed black printed stroke. All different chromaticity co-ordinates obtained for this sample is shown in Table 2. Plot of these co-ordinates in chromaticity diagram is shown in figure 5, figure 6 and figure 7. From all these chromaticity diagrams, it is clear that chromaticity co-ordinates (represented by +1, +2 and +3) of first stroke by red cello techno tip pens are overlapped and clustered. Also, chromaticity co-ordinates from black printed strokes (represented by +4, +5 and +6) as well as that of crossing stroke (represented by +7, +8 and +9) are grouped at same place. Except +8, all others are nearly overlapped with each other which is according to our fundamental assumption.

Table 2: Different chromaticity co-ordinates where numbers 1, 2 and 3 for first writing stroke by red cello techno tip pen; numbers 4, 5 and 6 for second black printed stroke by Canon LBP 3300 printer; numbers 7, 8 and 9 for crossing stroke

Number	X	Y	Z	x	y	u	v	L*	a*	b*	u*	v*
1	0.381	0.255	0.131	0.496	0.332	0.331	0.333	57.6	45.4	25.3	90.2	18.9
2	0.399	0.265	0.152	0.489	0.325	0.33	0.329	58.5	46.9	21.7	91.1	15.3
3	0.423	0.281	0.145	0.498	0.331	0.333	0.332	60.0	47.8	25.9	95.6	19.3
4	0.152	0.149	0.165	0.327	0.32	0.211	0.31	45.5	1.8	-3.7	0.4	-4.8
5	0.101	0.099	0.108	0.329	0.32	0.213	0.311	37.6	2.1	-2.9	1.1	-3.8
6	0.082	0.08	0.09	0.325	0.319	0.211	0.31	34.0	1.5	-3.2	0.1	-4.0
7	0.067	0.064	0.069	0.334	0.32	0.216	0.311	30.4	3.1	-2.0	2.3	-2.8
8	0.203	0.169	0.197	0.357	0.297	0.244	0.305	48.1	17.4	-5.8	20.9	-10.5
9	0.063	0.06	0.066	0.335	0.318	0.218	0.31	29.5	3.4	-2.3	2.8	-3.1

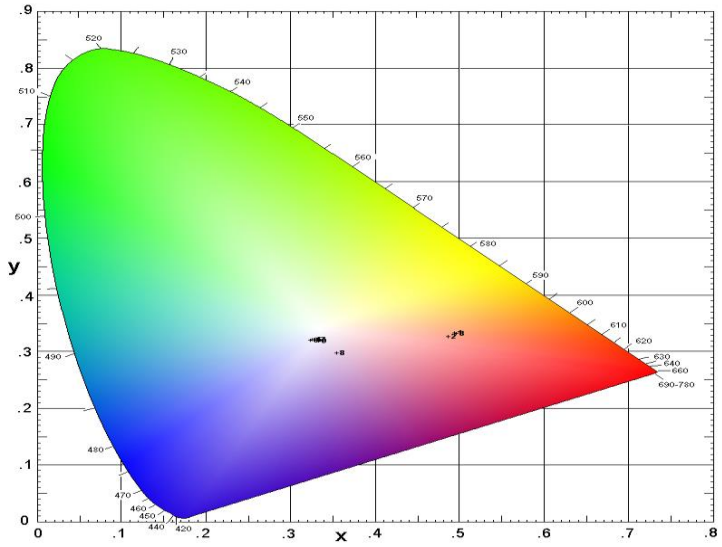

Figure 5: xy Chromaticity diagram generated by using Video Spectral Comparator (VSC)-6000 where +1, +2 and +3 represent for first writing stroke by red cello techno tip pen; +4, +5 and +6 represent for second black printed stroke by Canon LBP 3300 printer; +7, +8 and +9 represent for crossing stroke

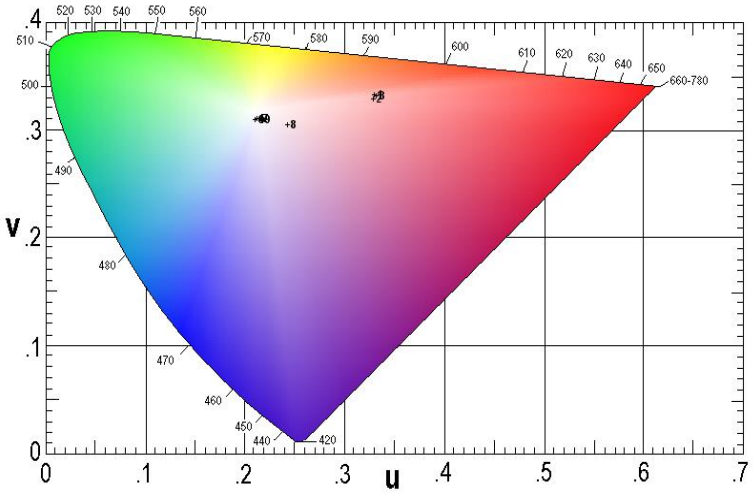

Figure 6: uv Chromaticity diagram generated by using Video Spectral Comparator (VSC)-6000 where +1, +2 and +3 represent for first writing stroke by red cello techno tip pen; +4, +5 and +6 represent for second black printed stroke by Canon LBP 3300 printer; +7, +8 and +9 represent for crossing stroke

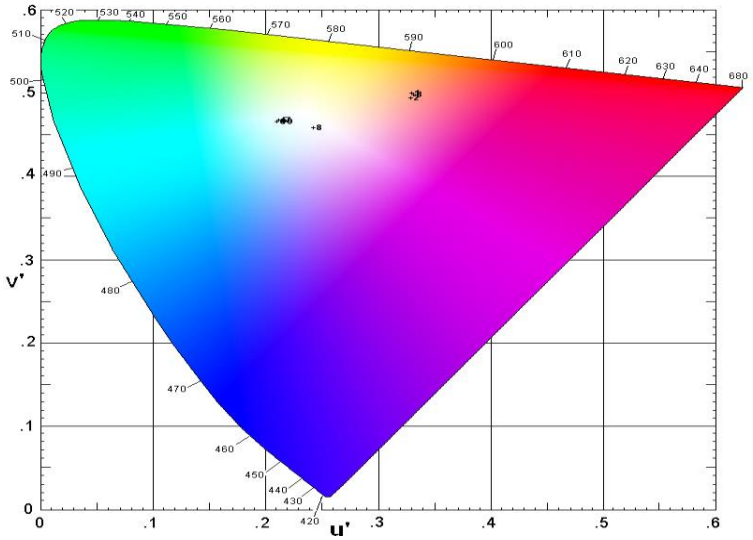

Figure 7: u'v' Chromaticity diagram generated by using Video Spectral Comparator (VSC)-6000 where +1, +2 and +3 represent for first writing stroke by red cello techno tip pen; +4, +5 and +6 represent for second black printed stroke by Canon LBP 3300 printer; +7, +8 and +9 represent for crossing stroke

5. Conclusion

We carried this work with nine different types of pens including cello maxriter pen (black and blue), pilot pen (red and black), cello pointec pen (black and blue) and cello techno tip pen (red, black and blue) found in local market of Nepal for pen strokes whereas Canon LBP 3300 is used for printed stroke to determine chronological order in crossing strokes by analyzing chromaticity diagram generated by VSC-6000. We started our work with the assumption that chromaticity (x,y) of the crossing stroke should be similar to that of second stroke. This experiment is done in the case of both homogeneous and heterogeneous crossing strokes. We have concluded our results as follows:

- We obtain completely negative and inconclusive results in the case of crossing strokes where pen stroke is made over printed stroke for both homogeneous (crossing stroke of same colors) and heterogeneous (crossing stroke of different colors) crossing strokes.
- Negative and inconclusive results are observed in homogeneous crossing strokes where printed stroke is over pen stroke.
- But we get positive and conclusive results in heterogeneous crossing strokes where printed stroke is over pen stroke.

Further studies can be carried out taking other different writing instruments and printers to find more conclusive results. In genuine documents, signature is done after printing whereas in fraud documents, print is done over signature. So, this work is very helpful to solve this challenging problem of document examination field.

References

Bieske, K, Csuti, P, & Schanda, J, 2007. Colour Appearance of Metameric lights and Possible Colorimetric Description. Poster on the CIE Symposium on Appearance, Peris, France.

CIE Techn. Report, 2006. Fundamental Chromaticity Diagram with Physiological Axis. Part-1, Publ. CIE.

Giri, R, Bhattarai, P, Chimouriya, SP, & Ghimire, BR, 2021. Examination of Security Features in Nepali Currency of Denomination Rs. 500 and Rs. 1000 Using Video Spectral Comparator-6000' Journal of Nepal Physical Society, vol 7, pp 36-42.

Gupta, AK, Rai, G, & Chaugh, OP, 1987. Determination of writing sequence of strokes of ball-point pen versus ball-point pen and other conventional writing instruments. Forensic Science International, vol 34, pp 217-223.

Gupta, RR, & Ravi, N, 2017. Passport Forgery and Forensic Examination of Indian Passport. Journal of Forensic Sciences and Criminal Investigation, vol 5.

Gupta, S, Gupta, K, & Singla, A, 2016. Advancement in Indian Passport-A Forensic Perspective. International Journal of Engineering and Technology, vol 3, pp 585-591.

Kaur, R, Saini, K, & Sood, NC, 2013. Application of Video Spectral Comparator (absorption spectra) for establishing chronological order of intersecting printed strokes and writing pen strokes. Science and Justice, vol 53, pp 212-219.

Manal, AE, & Abd, E, 2014. Different types of ink having certain medicolegal importance: Deciphering the faded and physically erased handwriting' Egyptian Journal of Forensic Sciences, vol 4, pp 39-44 .

Mann, M, Pathak, SR & Shukla SK, 2019. Three-dimensional detection of strokes using confocal microscope. Egyptian Journal of Forensic Sciences vol 9.

Mann, M, Purba, MK, & Shukla SK, 2013. Determination of Sequence of Strokes Using Docubox Dragon. J Forensic Res.

Moorthy, TN, & Narayanan, k, 2016. Enhancement of Handwriting on Selected Charred Documents using Video Spectral Comparator (VSC)' Arab Journal of Forensic Sciences & Forensic Medicine.

Osborn, AS, 1929, Questioned Documents. Boyd printing company, Second Edition.

Pandey, RK, Sankhla, MS, & Kumar R, 2018. Forensic Investigation of Suspected Document for Alteration, Erasures & Obliteration. Galore International Journal of Applied Science and Humanities, vol 2.

Pathak, SK & Paul, A, 2019. Spectral Analysis of New Indian Currency of Denomination 500 Using VSC-5000. International Journal of Innovative Science Engineering & Technology, vol 6, pp 120-135.

Spagnolo, GS, 2006. Potentiality of 3D laser profilometry to determine the sequence of homogeneous crossing lines on questioned documents. Forensic Science International vol 164, pp 102-109.

Suresh, M, & Jain, K, 2013. Sub Pixel Analysis on Hypothetical Image by using Colorimetry. International Journal of Recent Technology and Engineering, vol 2.

Vaid, BA, Rana, RS, & Dhawan, C, 2011. Determination of Sequence of Strokes Through Reflection Spectra. Problems of Forensic Science, Vol-LXXXVII.