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Application of absorption of infra-red radiation and reflection spectra to distinguish different inks of same color in alteration

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ABSTRACT

The main aim of this study is to introduce non-destructive method to distinguish different types of ink of same color. In our daily life, we face many problems of alteration of genuine documents. Such alteration is done by using same color of ink as used in the document. It is not possible to differentiate the altered part by our naked eyes. There are many methods, destructive as well as non-destructive methods, to solve the problem of alteration. We have discussed the non-destructive method using Video Spectral Comparator (VSC)-6000. Analysis is carried out with application of infra-red (IR) radiation of different wavelength and reflection spectra to reach the conclusion. Absorption of infra-red (IR) radiation is found very effective whereas use of reflection spectra is totally failed in this experiment.

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1. Introduction

Genuineness and authentication of documents like bank cheque, power of attorney, property paper, school college certificates, medical bills etc. depend upon the ink and material used to make the documents. Ink is colored liquid used to produce colored surface in different fields

like painting image, text or any kind of design. Major raw materials used for ink production are pigments, binders, solvents and additives. Pigment is chief constituent of ink and contributes 50% of its cost. A pigment is essentially any particulate solid-colored, black, white or fluorescent which alters the appearance of object by selective absorption or scattering of light. As the particle size reduces, the color intensity of pigment increases. Resins bind the ingredients of ink together [1].

Documents are also made with stamp, embossing, watermark and so on to prevent from forgery. But sometime genuine document is altered by using another ink of same color for personal benefit. Such alteration can be done on any part of document like date, amount, name, signature etc. to hide originality of documents. Destructive method like thin layer chromatography (TLC), destroys some parts of document. So, it is better to carry out non-destructive methods at first as much as possible. Non-destructive methods does not change document physically and involves use of different light sources and interaction of light with ink in different ways like absorption, reflection, luminescence etc [2].

S.R. Khairkar *et al.* [3] studied fraud cases and questioned documents of India based on alteration. They analyzed 6 different types of blue ballpoint pen inks (Reynolds, Parker, Lexis, Cello gripper and local pen found in India) by using VSC-5000. H.K. Bamburde *et al.* [4] studied about obliterated writing on questioned documents by the application of VSC-6000. Similarly, R.K. Pandey *et al.* [5] did work on alteration, erasures and obliteration on suspected documents. Also, T.N. Moorthy *et al.* [6] studied to enhance handwriting on charred documents by the application of VSC-6000.

But still we do not find any research work on the alteration from various inks found in the local market of Nepal. So, we have decided to carry out this work. This work is very useful to questioned document examiners and forensic researchers. This method is convening, lucid, illustrative and easy to perform by document examiners.

2. Theory

Different materials have different tendency of absorption and reflection. So, this work is basically based on the absorption of infra-red radiation and fundamental laws of reflection of light.

2.1 Absorption of Infra-red radiation

Infra-red (IR) spectroscopy simply deals with absorption measurement of IR radiation of different wavelength by a sample placed in the path of IR beam. Infrared radiation covers section of electromagnetic spectrum having wavelength roughly from 700 nm to 1 mm**.** IR absorption positions are generally represented in terms of either wavenumber or wavelength. Wavenumber is the number of waves per unit length. If frequency of IR radiation is matched with the vibrational frequency of molecule, then molecule absorbs IR radiation [7].

Hence, IR spectroscopy is based on Hook's law. According to Hook's law, frequency of vibration of two atoms or masses connected through spring (bond) is given as

$$\nu = \frac{1}{2\pi}\sqrt{\frac{k}{\mu}} \qquad (1)$$

'k' is force constant of the bond and 'μ' is reduced mass. If m_1 and m_2 are masses of two atoms, then reduced mass is given as

$$\mu = \frac{m_1.m_2}{(m_1+m_2)} \qquad (2)$$

Absorption of IR radiation by molecules results in the excitation of vibrational, rotational and bending modes while molecules remain in its electronic ground state. IR analysis involves the characterization of a materials with respect to presence or absence of a specific group frequency associated with one or more fundamental modes of vibration. Absorbance or co-efficient of absorption (A) is the

logarithm to the base 10 of reciprocal of transmittance (T) i. e.

$$A = \log_{10}\left[\frac{1}{T}\right] = -\log_{10}T \quad (3)$$

Here, transmittance (T) is the ration of radiant power transmitted by the sample (I) to the radiant power incident on the sample (Io).

2.2 Laws of Reflection

When beam of light falls on any surface, part of it is reflected, a part of it is transmitted and rest of it is absorbed. According to first law of reflection: the incident ray, reflected ray and normal to the surface lie in the same plane. This law implies that reflection is surface phenomenon i.e. reflected ray essentially characterize the surface from which it is reflected [8]. When we write above any surface, there is a deposition of thin layer of ink. Hence, reflection spectra from the ink layer of genuine and altered part may be different.

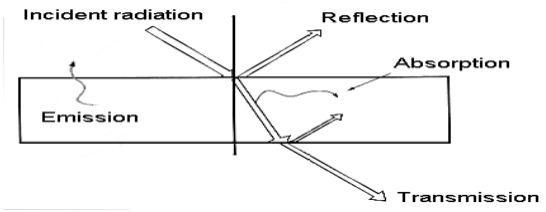

Fig. 1: Phenomena of reflection, transmission and absorption when an incident rays falls on a surface

3. Materials and Method

We prepared some samples of alteration by ourselves using different black ink pen (black pilot pen, black cello techno tip pen, black maxriter pen and black cello pointec pen) found in our market now days in white photocopy paper. We choose black ink pen because in most of the documents black pen is used. In our sample, digit one '1' is altered to make digit four '4' as shown in figure 3 and figure 6 by using different black ink pens. Such samples can be prepared in number of ways. For this study, we use Video Spectral Comparator (VSC)-6000 which works on the principle of interaction of light of different wavelength with matter.

3.1 Video Spectral Comparator-6000

Video Spectral Comparator (VSC) is very useful tool in document examination which allows an examiner to analyze ink [9], visualize hidden security features [10,11], crossing stroke examination [12,13] and reveal alteration in document. It is an automated device 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. After placing the document, infra-red light of various wavelengths is passed and absorption of IR light by ink is studied. Also reflection spectra from different points of genuine and altered part is observed. Once the required result is obtained, the image is saved.

Fig. 2: Video Spectral Comparator-6000

At first, we observed our prepared sample under normal light and then into spot light with IR radiation of different wave length. Finally, both results with normal light and IR radiation are analyzed.

For the study of reflection spectra, spectra form three to five different points of strokes produced by each pen is taken by using spectrometer available in VSC-6000 with reference to white back ground of photocopy paper. Then, average of thus produced spectra is taken with the help of software available in equipment. Finally, nature and characteristics of average of spectra of two strokes produced

by different pens are studied and compared to come to conclusion.

4. Results and Discussion

Though, we see the same color of ink but their composition may be different. If their composition is different, then absorption and reflection properties also will be different. This concept is useful to this work. In all samples, we altered digit one into digit four. We obtained good results in all cases but only results of two of them are discussed here.

4.1 Alteration from black cello techno tip pen and black cello maxriter pen

Under visible light digit four '4' is seen as shown in figure 3 which is written by using two different black pens cello techno tip and cello maxriter. But under spot light with IR radiation of wave length 645 nm altered part made by using cello maxriter is absorbed more as shown in figure 4. So, from these two results, two different black colored inks are differentiated. In figure 5, we have an average of reflection spectra obtained from these two inks. From this graph, we find similar nature of both spectral lines indicating negative result against our basic assumption because we expect difference in nature and peak character between these two spectra.

Fig 3: Prepared sample of alteration under visible light where at first digit one (1) is written with black cello techno tip pen which is altered into digit four (4) using cello maxriter pen

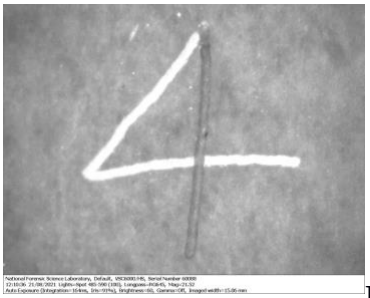

Fig. 4: Prepared sample of alteration under spot light with IR radiation of wave length 645 nm where at first digit one '1' is written with black cello techno tip pen which is altered into digit four '4' using cello maxriter pen

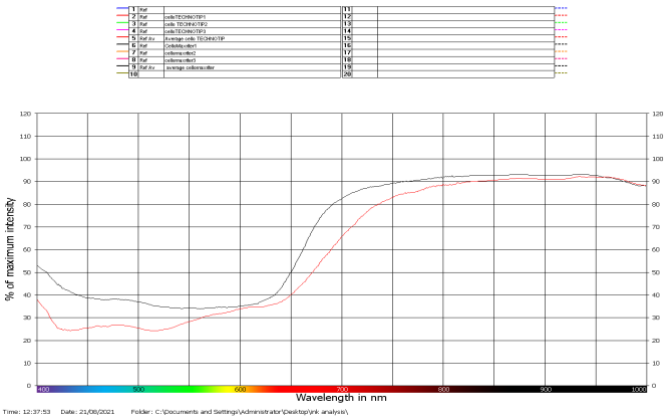

Fig. 5: Average of reflection spectra from three different points of strokes made by black cello techno tip pen (red line) and black cello maxriter pen (black line)

4.2 Alteration from black cello pointec pen and black pilot pen

Similarly, in the next sample prepared from black pilot pen and black cello pointec pen, under visible light digit four '4' is seen as shown in figure 6.

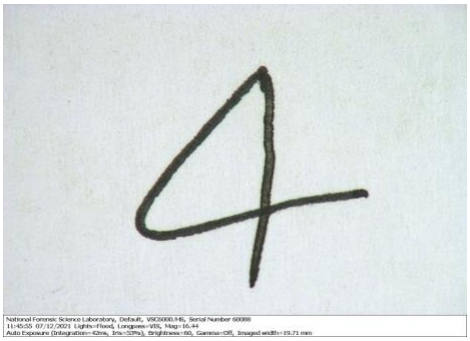

Fig 6: Prepared sample of alteration under visible light where at first digit one (1) is written with black cello pointec pen which is altered into digit four (4) using black pilot pen

Under flood light with IR radiation of wavelength 780 nm, altered part made by using black pilot pen is absorbed more as shown in figure 7. In figure 8, we have an average of obtained reflection spectra. Here, also we do not get difference in nature and peak character between these two spectral lines in graph which means application of reflection spectra to study alteration is failed.

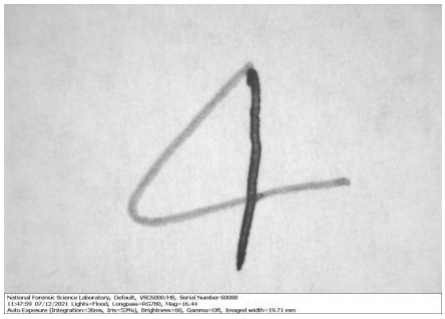

Fig. 7: Prepared sample of alteration under spot light with IR radiation of wave length 780 nm where at first digit one '1' is written with black cello pointec pen which is altered into digit four '4' using black pilot pen

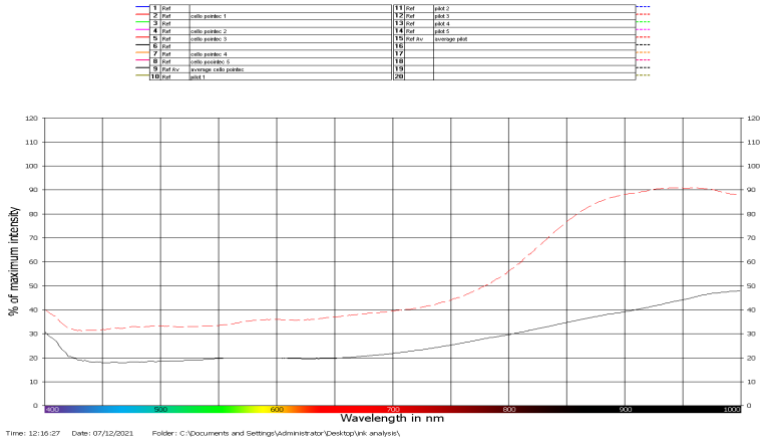

Fig. 8: Average of reflection spectra from five different points of strokes made by black pilot pen (red dot line) and black pointec pen (black solid line)

5. Conclusion

In this work, we took very simple case of alteration where digit one '1' is altered into digit four '4' by using four different black color pens. We successfully differentiated altered parts by analyzing absorption of infra-red (IR) radiation but reflection spectra is not found effective. So, we can suggest to use concept of absorption of IR radiation not reflection spectra to solve problem of alteration to document examiners.

References

[1] B. R. Sharma. Forensic Science in Criminal Investigation & Trails, Universal Law Publishing Co. Pvt. Ltd. (2014).

[2] A. S. Osborn. Questioned Documents, Boyd printing company, Second Edition, (1929).

[3] S. R. Khairkar, S. V. Gaikawad, R.N. Kokare and B.B. Daundkar. Forensic Discrimination Potential of Video Spectral Comparator and Micro Spectrometer in Analyzing Question Document and Fraud Cases in India, J. Forensic Res. 7(2016) 1-4.

[4] H. K. Bamburde and M. P. Goutam. Questioned Documents Analysis for Decipherment of Obliterated Writing, Int. J. Sci. Res. 9(2020).

[5] R. K. Pandey, M. S. Sankhla and R. Kumar. Forensic Investigation of Suspected Document for Alteration, Erasures & Obliteration, Galore Int. J. Appl. Sci. Hum. 2(2018).

[6] T. N. Moorthy and K. Narayanan. Enhancement of Handwriting on Selected Charred Documents using Video Spectral Comparator (VSC), Arab J. Forensic Sci. & Forensic Med. *(*2016).

[7] D. L. Pvia, G. M. Lampman, G. S. Criz and J. R. Vyvyan. Introduction to Spectroscopy, Cengage Learning, Fifth edition, (2015).

[8] B. A. Vaid, R. S. Rana and C. Dhawan. Determination of Sequence of Strokes Through Reflection Spectra, Prob. Forensic Sci. Vol-LXXXVII, (2011).

[9] A. E. Manal, and E. Abd. Different types of ink having certain medicolegal importance: Deciphering the faded and physically erased handwriting, Egyptian J. Forensic Sci. 4(2014)39-44. .

[10] N. K. Kanwal, D. Jat, M. Malhotra. Spectral analysis of various security features in the Indian currency note of highest denomination using Video Spectral Comparator-40, Int.J.Innov. Sci. Eng. Technol.1(2015)823-841.

[11] R. Giri, P. Bhattarai, S. P. Chimouriya, and B. R. Ghimire. Examination of Security Features in Nepali Currency of Denomination Rs. 500 and Rs. 1000 Using Video Spectral Comparator-6000, J. Nepal Phys. Soc. 7(2021)36-42.

[12] R. Kaur, K. Saini and N. C. Sood. Application of Video Spectral Comparator (absorption spectra) for establishing chronological order of intersecting printed strokes and writing pen strokes, Sci. Just. 53(2013)212-219 .

[13] R. Giri, S. P. Chimouriya and B. R. Ghimire. Study of Chronological Order in Intersecting Printed and Pen Strokes with the Help of Chromaticity Diagram, Acta Scientifica Malaysia, 6(2022)38-42.