Research Article

HYPER SPECTRAL IMAGING AS A TOOL FOR FRAUDULENT DOCUMENT INVESTIGATION

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A R T I C L E   I N F O

A B S T R A C T

Now a day's document frauds increased rapidly in society. Forensic document examination (FDE) is most important branch in white collar crime investigation. Forensicdocument examination in conventional methods used for investigation like chemical methods and microscopic technique. In this study focused on Hyperspectral imaging (HSI) emerging tool for fraud document assessment.Hyperspectral imaging (HSI) as a non-invasive technique, has evolved as a tool in forensic analysis especially in cases of forensic document examinations. In this paper this most useful tool has been explored for forensic document examination. In document examination frequently issues of forgery of printed document, seal impression and fingerprint are encountered. Normally these prints are often questioned on its authenticity. Many times in document that prints on each other and form a smudge area on document. This smudge area is unable to observe writing, fingerprint, seal impression matter and arise question mark on its reliability. This paper is focused on distinguishing printed text, stamp impression and fingerprint on document. Here using VSC-6000/HS with HSI range is used to distinguish and photographs were taken for record.

INTRODUCTION

Forensic document examination became an independent discipline in last few decades. In forensic document examination many cases of fraudulent documents, case of seal impression, case of fingerprint, case of typed matter (typewritten text, thermal printed text, inkjet and laser printed text) frequently noticed. This type of case investigation in use microscopic technique, chemical test, illumination technique etc. but Hyperspectral imaging (HSI) is a powerful tool for forensic document examination. HSI is new immerging tool in forensic document examination. HSI application in various fields of research. Wide range of HSI applications are reported in art and archaeology, imaging, military, pattern recognition and remote sensing areas (KhanZ *et al* 2013). HSI is commonly used for in old documents visual enhancement and to create reconstructed fine image (Joo Kim S *et al* 2011).National archives of Netherlands have developed software for historical document examination(GoltzD *et al* 2010).The developed sophisticated system provides range from near UV, visible to NIR(Klein ME *et al* 2008). Investigators use HSI for the evaluation and identification of forensic trace evidences (EdelmanGJ *et al* 2012). The non-destructive manner of development of HSI system is put into use for enhancing the valuation of visual properties of stains.

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Manual visual comparison of black inks in lab color mode was reported by using HSI system Hammond *et al*(Hammond DL *et al* 2007) also reported the writing ink detection efficient HSI system for different types of ink analysis was, where dissimilar ink show divergence in spectra (KhanZ *et al* 2013). Detection and enhancement of untreated latent fingerprint impression using HSI system is studied and reported by many reasearchers(Crane NJ *et. al* 2007, Exline DL*et al*. 2003, PayneG *et. al* 2005, Tahtouh M *et. al* 2005, Tahtouh M *et. al* 2007, Bhargava R *et. al* 2009). It is also used for chemically treated latent finger prints development and recognition (ChampodC *et al* 2009, MiskellyGM *et al* 2005, Maynard PJ *et al* 2009, Tahtouh M*et al* 2011). HSI is a technique in the examination of gel pen writing ink, which enables the detection of subtle difference among chemically similar inks(Reed G*et al* 2014). Non- destructive visual examination of document by microscopy and filtered light IR (infrared) and UV (ultraviolet) lighting, including thin layer chromatography (TLC), high performance thin layer chromatography (HPTLC) (WeyermannC *et al* 2007, NeumannC *et al* 2009), HPLC, capillaryelectrophoresis(CE), gas chromatography(GC) alternative chemical technique is destructive methods(Kher AA*et al* 2001, ManiaJ *et al* 2002, Bügler JH*et al* 2005, Thanasoulias NC *et al* 2003). Other spectroscopic technique in UV-vis-spectroscopy (Causin V *et al*2008, Adam CD*et al* 2008, RouxC *et al* 1999), microspectrophotometry(MSP) (KherA *et al* 2006), Fouriertransform infrared spectroscopy (FTIR) (KherA *et al* 2006, Causin V*et al* 2008, JonesAW*et al* 2003), Raman spectroscopy (Mazzella WD *et al* 2003, Claybourn M*et al* 2000, WhitePC2000, MazzellaWD*et al*

2005, Zieba-PalusJ *et al* 2008), Hyphenated mass spectrometry and Laser induced break down spectroscopy(LIBS) (Sakayanagi, M *et al* 1999, Maind SD *et al* 2006, Jones RW *et al* 2006, Dunn JD *et al* 2007, Papson K *et al* 2008, Williams MR *et al* 2009, Coumbaros J *et al* 2009, Gallidabino M *et al* 2011, Weyermann C *et al* 2011, Weyermann C *et al* 2012, TrejosT *et al* 2010) for minimal quantity of ink.

The goal of study was to in question document simultaneously examination of printed text,seal impression and fingerprint impression descrinatation and examination using Hyper spectral imaging non-invasive technique**.** This type of document frequnly encountered in forensic casework.

MATERIALS AND METHODS

Materials and instruments

Inkjet, laser, thermal printouts and typewritten paper obtained from the local market. Inkjet printer and laser printer along with original cartridge then printout on A4 size paper (80gsm). Thermal printout obtain from ATM centre of bank. Typewritten text matter typed with local typist from market. For thumbprint impression used black fingerprint ink. Stamp pad used for seal impression. In this study used instrument Video spectral comparator (VSC) 6000/HS by froster & freeman, UK. The Instrument is an assembly of various light sources, optical filters, CCD camera and high resolution grating spectrometer.

Sample preparation

In this study, in all 60 simulated samples comprise inkjet print (15 samples), laser print (15samples), thermal print (ATM slips, 15 samples) and typewritten (15 samples) were investigated. Care has been taken that printers should have original cartridges as recommended by manufacturing company. For sample preparation, white A4 size printer paper (82 gsm, 210 × 279 mm) was used for obtaining printed text from different sources viz. inkjet, laser, typewriter and for thermal print samples with pre-printed ATM transaction slips were obtained. All the printed samples were further stamped by blue rubber seal impression (stamp pad ink) obtained from local market, which were further smudged with fingerprint impression by standard fingerprinting ink. In questioned document this type of cases frequently occurred. Many a times fingerprints are also to be considered in questioned document examination because at instances thumb impression is used as signature by illiterate person in documents. All simulated samples created examination purpose only. In all 60 samples smudged with printed text, rubber seal impression and fingerprint were subjected to hyper spectral analysis for their discrimination.

Fig.1 is a prepared sample of printed text, seal impression and fingerprint (thumbprint) overlapped to each other on document.

Figure 1 (a) Inkjet group (b) Laser group (c) Thermal group (d) typewriter group -Simulated overlapped of printed text, seal impression and thumb print

Methods developments

The simulated samples were analysed under calibrated Video spectral comparator (VSC) 6000/HS by froster+freeman-UK. VSC-6000/HS allows examining document under various wavelengths of light. HSI is a one of feature for document examination in VSC-6000/HS. Hyperspectral analysis mode enables to analyse in visual examination. A range of HSI 400-1000 nm and different filter facilities for document examination HSI feature is used with 10 band-pass (bandwidth) filter steps within the range is used. Ultimately 130 images at every 10nm were obtained. Difference of wavelength absorbance is giving images at juxta position. Every single image photographed at 10nm difference and arranged in juxta position to comparable image chart. This visual examination is able to simultaneously discriminate among images at difference wavelength illustrating visual difference among different types of inks impression. A spot fluorescence at 695nm was also obtained to visualize fluorescence property in the sample. The method was repeated on all the samples under similar condition.

RESULTS

In presence study 60 samples analyzed using VSC 6000/HS. Given below the results in image chart and its observation in four group's 1. Inkjet, 2. Laser, 3. Typewritten,4. Thermal.

Inkjet group

In Fig.2 Inkjet group in printed text, seal impression and fingerprint smudge area in paper.This smudge part exposed under hyperspectral imaging mode it content different filter, visual and infrared condition (400-1000 nm). In chart of image in some blank images indicate unable to distinguish on that particular wavelength. In this images text area visible in 780nm to 840nm clearly. Seal impression is fluorescence in spot fluorescence condition. Fingerprint one of discriminate from both impressions under filter light condition.
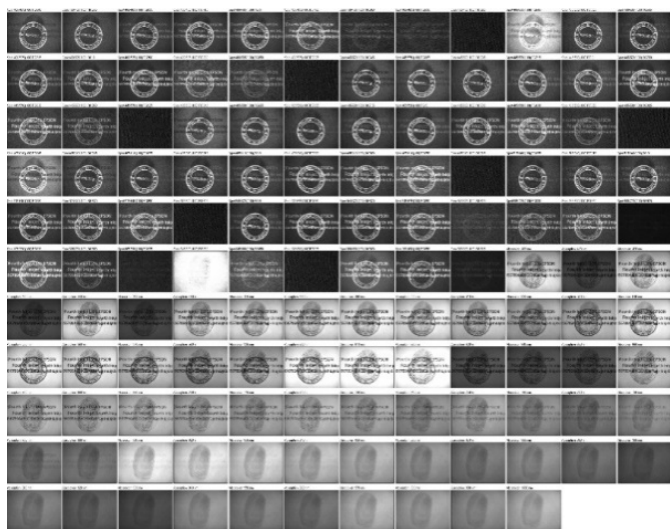
Figure 2 Image matrix of inkjet printout with smudge area.

Laser group

Laser group image chart following 130 images showing absorbance at various wavelength and give an individual image. In chart blank image have unable to differentiate on that wavelength. In images visible printed text, seal impression, and fingerprint in sequence. Laser printed text visible in 550nm to 590nm and seal impression visible in spot florescence condition. Fingerprint visibleclearly in filter mode.
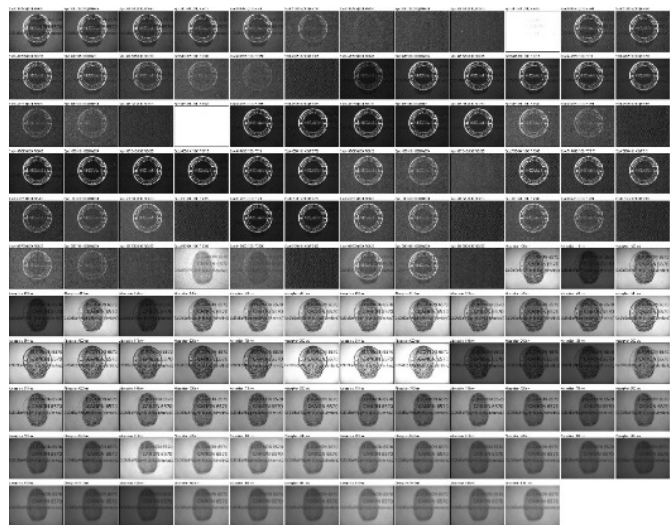

Figure 3 Image matrix of Laser printout with smudge area

Typewriter group

In Fig.4 typewritten group in printed text, seal impression and fingerprint smudge area in document examination under different filter, visual and infrared condition (400-1000 nm). Every 10 nm bandwidth wavelength one image taken within range 130 image chart. In chart of image in some blank images indicate unable to distinguish on that particular wavelength.

Thermal group

Thermal group image chart following 130 images showing absorbance at various wavelength and give an individual image. In chart blank image have unable to differentiate on that wavelength. In images visible printed text, seal impression, and fingerprint in sequence in Fig.5
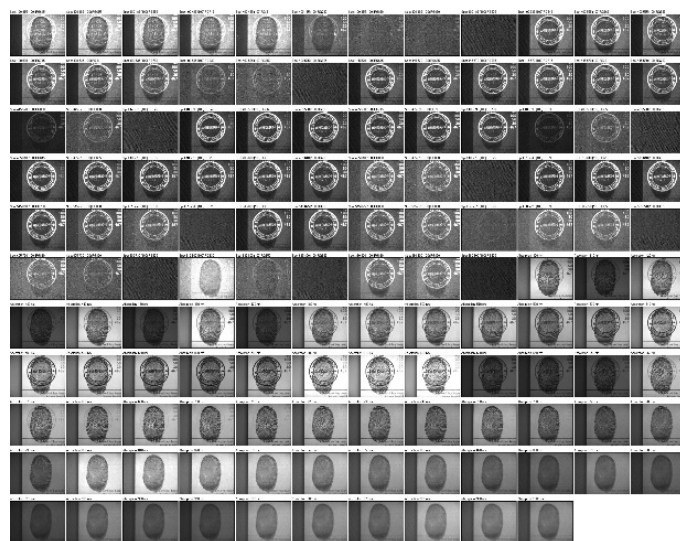

Figure 4 Image matrix of typewritten with smudge area

Figure 5 Image matrix of thermal printout with smudge area

In Table 1 inkjet, Laser, typewritten, thermal groups sample discrimination in different wavelength and using different types of filters. In the table samples including text which is printed by inkjet, laser, and thermal and typed using typewriter are discriminated in different range.

Table 1 Inkjet, Laser, typewritten, thermal group samples discrimination in different wavelength and filters

Sample	Inkjet group	Laser group	Typewritten group	Thermal group
Text (printed/typed)	780nm to 840nm	550mn to 590nm	670nm to 900nm	Spot fluorescence
Seal impression	Spot fluorescence	Spot fluorescence	Spot fluorescence	Spot fluorescence
Fingerprint	Filters(RG830,850,925)	550nm to 590nm	660nm to 900nm	660nm to 900nm

CONCLUSION

The HSI potentialof discriminating over the other analytical techniques for inkjet, laserand typewriter, thermal ink from stamp-pad and fingerprint ink analysis has been examined. HSI Discrimination relies upon the view of the examiner. The changes in the responses of the ink under visible and IR condition at specific wavelengths in combination with comparison of image differences between inks, greatly assists

discrimination. HSI provided a complete discrimination of all inkjet, laser, typewritten, thermal from stamp-pad and fingerprint ink examined. Particularly examine individually questionable matter in document using HSI.The discriminating power of this method is 0.93. HSI is non-destructive in nature so that differ from conventional methodology. This HSI tool easy, handy and less time consuming with accurate for question document examiner.

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