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# Analysis of Questioned Documents: A Review Analysis of Questioned Documents with Video Spectral Comparator and ESDA also Examining the Forged Signatures

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## Abstract

Questioned document analysis involves the comparing of document with the known writing or documents and find out the erasures, alterations, obliterations in document. Any kind of forgery done in any document is known as questioned document. This paper describes the use of Video Spectral Comparator 6000 (VSC) and the ESDA (Electro Static Detection Apparatus). VSC works with different light sources and find out the forgery in any kind of document such as suicide notes, currency notes, passports, stamp papers, ID, agreement, check, bank draft etc. ESDA is useful for finding the indented writing or hidden writing. Low angle oblique light and photography were used to identify and decode indented text. Recently, an Electrostatic Detection Apparatus (ESDA), has been utilized to provide a visual picture of the indented text on transparency film. Those writing that are hidden below written pages due to pressure of ball point or pen.

In this article also review the forged signature identification with helps in finding the forged signature by examine different features of identification. This paper serves three purposes: finding any kind of forgery through VSC, helpful to identify the hidden writing and identification of forged signatures.

Several forensic professions compare the evidence to well-known things in order to ascertain its origins. The Analysis, Comparison, Evaluation and Verification (ACE-V) approach is a comparative technique used in several forensic fields. The ACE-V technique gives the examiner a structure to follow while they carefully evaluate the evidence.

**Keywords:** Document • Video Spectral Comparator 6000 (VSC) • ESDA (Electro Static Detection Apparatus) • Agreement

## Introduction

The study of suspected papers using science is known as questioned document examination. Any handwritten or typewritten document with questionable handwriting, a signature, a mark or a source qualifies as a questionable document. It is not feasible to simulate everything perfectly. The forger attempts to replicate the form, size, style, slant and other general qualities of real signatures or documents while mimicking them. To complete this assignment, he must remember the visual qualities of real signatures and be able to reproduce them on paper in a comparable manner. The forger is also troubled by his dread of punishment for carrying out such a wrongdoing. His mental stress responses also make imitation challenging, preventing him from perfecting it. So the forger leaves the traces that identifies with different methods and techniques. In this work we find out the forgery in documents by Video Spectral Comparator 6000 (VSC) and ESDA. VSC is a very helpful tool in document examination that enables an examiner to analyze ink, reveal document alterations, visualize hidden security features in money, passports, etc. determine the chronological order of crossing strokes, enhance writing on charred documents, etc. The VSC is turned on for the first time and the proper settings are made before operating. Paper money is put on a document platen below a canopy in the VSC chamber, which also houses a video camera, sources of reflected light and optical filters. A video picture is then shown on a monitor. By watching on the display, you may change the location of the money. To get the desired results, several lighting choices in the UV (200 nm-400 nm), Visible (400 nm-700 nm) and IR (700 nm-1000 nm) wavelength ranges, illumination geometries, various optical filters

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and various magnifications are chosen once the currency note has been placed. The image is stored when the desired outcome has been attained. ESDA used for recovering impressions from documents. The Electrostatic Detection Apparatus (ESDA) is a tool for visualizing indentation imprints on questioned papers. This paper analyses some of the variables known to impact ESDA findings as well as those variables that have yet to be addressed. Variables under examined included: investigating the impact of varying amounts of indentation on different paper characteristics with different pressure of ball point, pen or pencil. In this paper also described the identification of forged signature and features of identification.

## Materials and Methods

### Video spectral comparator 6000

Video spectral comparator is a digital imaging system combining high resolution image optics and multi-spectral illumination with a powerful software package that includes different type of tools for image enhancement and decoding digitally encrypted data. This system is provided by foster freeman. It is a company that make machines used in forensic sciences, that is connected to PC and shows the results on the desktop. VSC revealed different features in a questioned document that are not seen with a naked eye [1].

It is useful in document examination, ink examination, visualize the hidden security features of document, currency, passport or suicide notes etc. Different light sources are used for the examination of document. For example, first of all switch-on the VSC place the paper currency placed under the canopy in the chamber. This chamber contains the high quality video camera. The sources of optical filter and reflected light creates a video image that is shown on the monitor [2]. After the currency note is placed in VSC, various illumination options in the range:

- UV (200-400 nm)
- Visible (400-700 nm)
- IR (700-1000 nm)

Set up in VSC:

- VSC 6000 consist of a main unit and a PC-system which is windows based.
- High resolution CCD fire wire camera exist in main unit.
- The sensitivity of camera is 360 nm-1100 nm.
- Different light sources, optical filters and Trans light panel are situated in main unit.
- The panel is located in the center of document platen.
- Under the panel, light sources are located that illuminates the document from below.
- The document platen is 650 mm × 650 mm and light panel is 235 mm × 175 mm.
- In the video spectral comparator there is also a high-resolution grating spectrometer which can analyze the light from small region in the document.

There are four different light sources in VSC that used to help out the different features in the questioned document (Figure 1). These light sources are explained above in Table 1.

**Table 1.** Light sources in VSC.

| Lamp type | Wavelength(nm) | Main sources |
|---|---|---|
| Vapor discharge tubes | 365 (UV-A) | Transmitted lighting |
| | 313 (UV-B) | Reflected lighting (UV) |
| | 254 (UV-C) | |
| Flash tube | 850-1100 (IR) | Anti-Stokes flash |
| LED | 400-700 Visible | Coaxial lighting |
| | | Diffracted lighting |
| Incandescent filament lamps | 400-1000 Visible+IR | Flood lighting |
| | | Transmitted light |
| | | Spot lighting |
| | | Transmitted lighting |

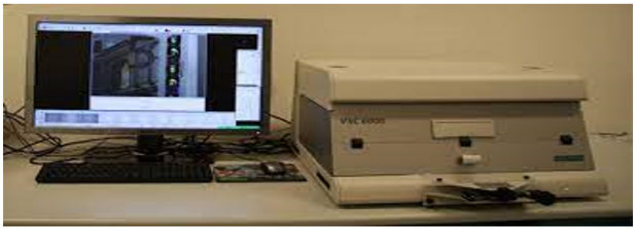

**Figure 1.** VSC apparatus.

### Analysis of paper currency through VSC

Many methodologies and scientific steps that are used to find out the security features in paper currency but we can find out security features of Nepali currency through VSC. Security features are find out on paper currency of Nepal Rs.500 and Rs.1000 using VSC-6000.

**Watermark and Fluorescence:** Watermark is present in the paper currency of Nepal in the RS.500 and RS.1000 notes. When viewed with transmitted light in VSC there is clearly visible watermark of Laliguarish is appeared. Watermark is a design that produced in the particular space of currency. It looks like three dimensional figure and not clearly visible in normal light. That's why transmitted light helps in visibility of watermark whether the currency is original or fake [3].

The properties of fluorescence are observed and seen in the currency notes of RS.500 and RS.1000. For the currency note of Rs.500 optimum fluorescence effect is observed under the UV light of 365 nm wavelength while the same effect is observed in 254 nm wavelength for Rs.1000. Fluorescence in the number of currency, signature, figure of Everest and 1000 digit is seen. The part of Mount Everest figure and the digit are brighter than the signature and number of the currency note in Rs.1000 currency note. There are no changes for the Rs.500 note. The intensity of the fluorescence is same of both notes but if there is any fake note the fluorescence did not happen in fake currency note. So in that way VSC helps to find out the questioned currency notes (Figures 2-4).


**Figure 2.** Fluorescence on the reverse side of a Rs.500 coin from the 2012 series when examined under UV light with a wavelength of 365 nm.


**Figure 3.** Fluorescence on the reverse side of the Rs.1000 of the 2016 series as seen using UV light of wavelength 254 nm.

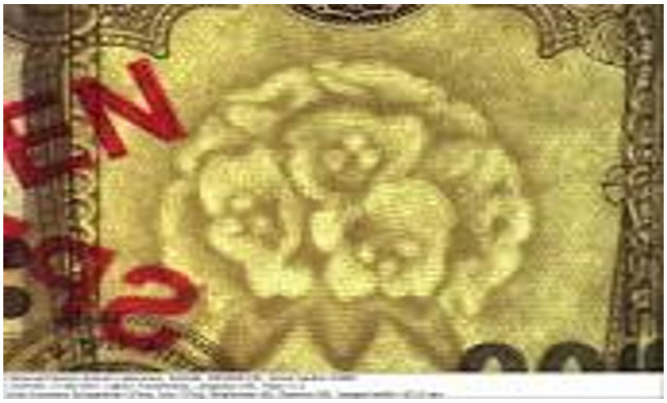

**Figure 4.** Under transmitted light, a water mark was seen in the Rs. 500 of the 2012 series.

## Analysis of Burnt or charred documents

A document is considered charred if it has burned or been exposed to extreme heat and has turned black and brittle. Documents that have been accidentally burned or purposefully damaged are sent to forensic laboratories for restoration and text decipherment. Due to their extreme fragility, burned papers frequently break into little pieces and do not retain their original shape. Additionally, curling is seen at edges [4].

It's pretty uncommon for people to burn papers to hide evidence of a crime; most of them think that after the evidence has been reduced to ash, they won't be found. However, a skilled document examiner can frequently still decipher what is on a burned or charred document with the use of specialized equipment [5].

### Equipment or material

- Video Spectral Comparator (VSC)
- Black ballpoint pen
- Blue ballpoint pen
- Printer paper
- Cue card

Alternative light sources, such as those present in infrared and ultraviolet wavelengths of light, can be used to visualise what has been written on paper even after that paper has been burned to the point and its contents are no longer readable. The Video Spectral Comparator (VSC), a relatively new piece of forensics equipment, is used to demonstrate that various light sources may be employed for similar objectives. Today, the VSC is extensively used for document and ink testing. It employs a high-quality camera as well as different lighting sources.

## Method

It would be ideal to utilise short three-letter sequences of letters because they only occupy a small portion of the page and the complete "word" may be identified by utilizing the VSC to concentrate on a limited region. Each sample has an empty space remaining since the sample's burning isn't always accurate. To provide a before-

and after comparison, each sample had its picture taken using the Video Spectral Comparator (VSC).

Each sample was burned in an oven before being removed and stored in a box. The samples were subsequently delivered to the VSC for evaluation with Alternative Light Sources (ALS). Each sample was examined in the VSC under every possible wavelength of light. UV light (300 nm-900 nm) and infrared light (300 nm-900 nm), as well as additional lighting alternatives such as coaxial lighting.

The charred samples were photographed under normal lighting, infrared lighting, UV lighting and co-axial lighting. It was noted which light sources produced the greatest results for each ink and paper combination, as well as which light was best for examining the burned documents [6].

## Results and Discussion

**Results of burned documents:** Under normal lighting, the text on each sample was not visible. Using infrared light sources, however, the text on each of these two samples became plainly visible. Co-axial illumination may also be used to read what had been written on the paper after it had been burned. UV illumination was useless for reading anything on the charred paper.

The other samples of black ballpoint samples also give the same results as blue ballpoint samples. The text on each sample could not be read under normal illumination (Figure 5). The text on each sample, however, could be rendered plainly apparent by utilizing co-axial illumination (Figure 6). In contrast to the blue ballpoint pen samples, infrared light sources were unable to reveal the writing on the charred pieces of paper. UV radiation was once again ineffective in revealing the contents of the charred documents (Figures 7 and 8).

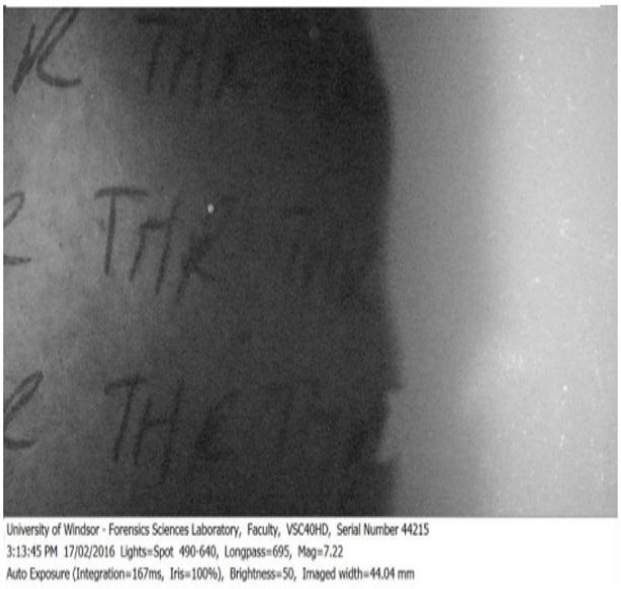


**Figure 5.** The result of infrared lightning used to visualize the words on burnt documents.

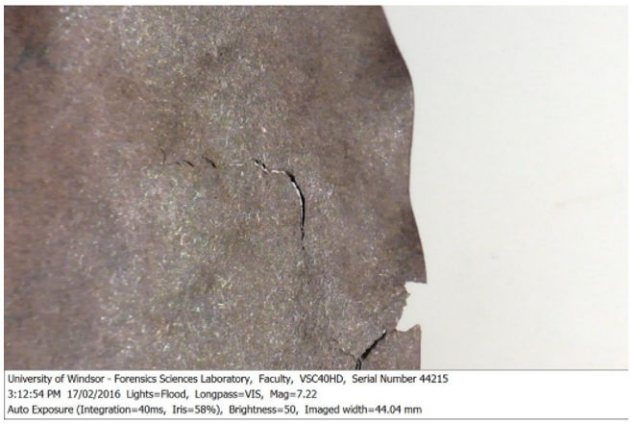


**Figure 6.** The blue ballpoint pen that was used to write on the charred paper is no longer visible.

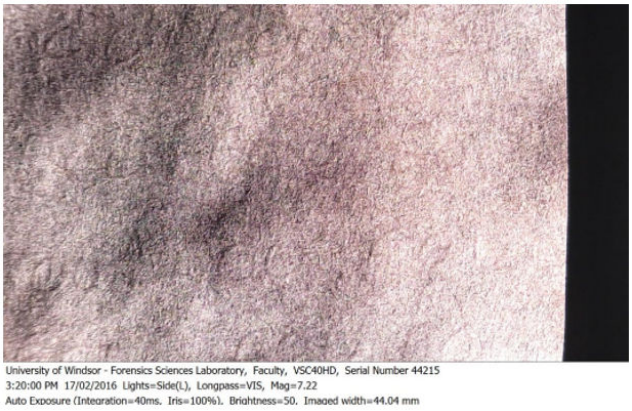


**Figure 7.** A demonstration of co-axial illumination used to see a black ballpoint pen on burnt paper.


**Figure 8.** The lettering in black ballpoint pen is obscured).

So, we successfully prove that the VSC machine works very effectively for the burn paper or documents. The lights of VSC need adjustment according to paper ink type and it can give you a very effective results.

### ESDA (Electrostatic Detection Apparatus)

Since 1978, Foster and Freeman Ltd. in Worcestershire has been producing the ESDA, which is principally used for recovering impressions from documents. The Electrostatic Detection Apparatus

(ESDA) is a tool for visualising indentation imprints on questioned papers. ESDA operates by electrostatically charging a paper that may contain suspected indented writing. By using charge-sensitive toner, the indented lettering is made visible. Then, on the pages above, indented writing (*i.e.*, disrupted fibres) from earlier written papers may be observed. This paper analyses some of the variables known to impact ESDA findings as well as those variables that have yet to be addressed. Variables under examined included: investigating the impact of varying amounts of indentation on different paper characteristics with different pressure of ball point, pen or pencil [7].

Indented writing, also known as second page writing, is the imprint made by the writing tool on sheets of paper beneath the one containing the initial writing. This is common when using pads of paper or in various record-keeping circumstances. Indented writing can be used to identify people in anonymous note instances and can be a significant investigative tool when medical and other documents are suspected of being altered. A written addition to a document or file is frequently disclosed by an impression transmitted to the page below. Indented text on succeeding pages may differ from what appears on the document's surface. Writing discovered to be out of place, missing or added after the event may frequently be corrected.

**Process:** Indented writing was identified and deciphered by means of low angle oblique light and photography. More recently, an instrument known as an Electrostatic Detection Apparatus or ESDA, is used to produce a visual image of the indented writing on transparency film. If applicable, this procedure is non-destructive and rather non-detectable. ESDA works by generating an electrostatic picture of indented writing, which is subsequently rendered visible by the use of charge sensitive toners. This precise imaging technology detects tiny damage to fibres at the surface of a paper caused by abrasive contacts with overlaying surfaces during handwriting (Figure 9).

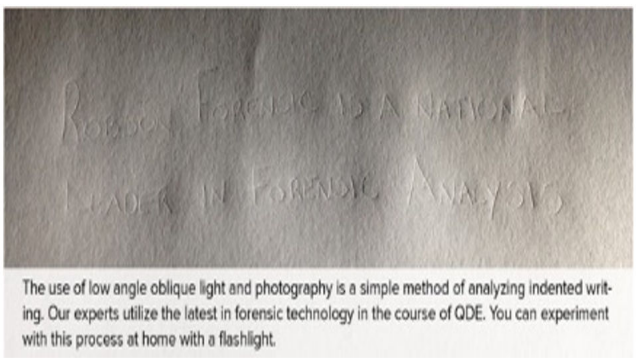


**Figure 9.** Use of low angle oblique light.

Latent intended writing flow chart: If the document has been maintained in a dry atmosphere or has a dry source, it may need to be gently humidified. This will aid in the development of the electrostatic charge. An example of such an environment is an internal page from a pad of paper. Exposure to typical room air would accomplish the same benefit in humid areas. Most papers that are exposed to regular room settings with naturally humid air do not require preconditioning. The ESDA Humidifier can be used if necessary. A vacuum drawn through a sintered (porous) bronze plate draws a vacuum through the page suspected of having indentations, which is subsequently brought into solid contact with the paper. This is used to "fasten" the document and mylar covering together (Figure 10).

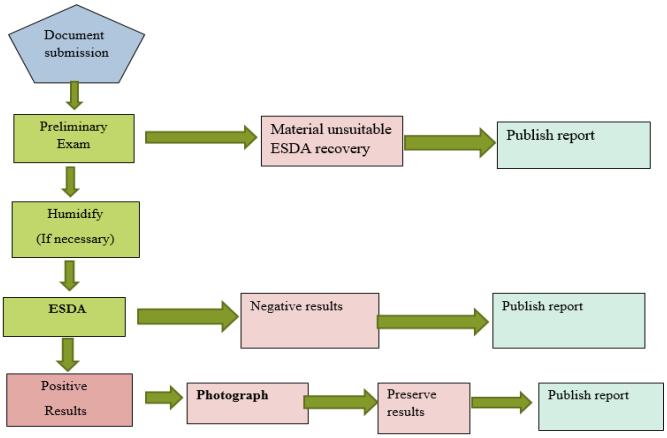


**Figure 10.** Latent intended writing flow chart.

Many elements influence the impressions formed and the extent to which they may be interpreted. However, impressions can be recovered up too many pages deep. The above example depicts a phone number, the imprint of which can be read on each of the five pages that were there under the original text (Figure 11).

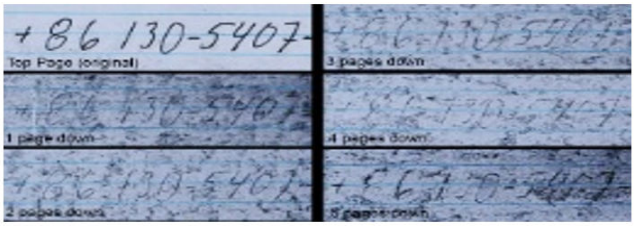

**Figure 11.** Recovering intended writing by ESDA.

## Forged signature identification

Today, signatures are extremely important and everyone, regardless of social class, must sign his or her name on a daily or multiple daily basis. Under these circumstances, the question of whether a challenged signature is authentic or not frequently arises.

A signature is defined as a name or a mark that a person places at the conclusion of a document to indicate that he is its creator or that he ratifies its contents. Those who are unable to read or write must sign with a simple cross. We have here the most basic signature, which, while it may have legal significance, does not provide much security since it lacks individuality. It is impossible to tell who signed because a simple cross cannot be used to identify a person. People with little writing abilities who merely write their name, with or without the initial name, write precisely as if they were writing a common name; they are abundant. The identification of the individual who signed is a little simpler with such signatures since that person is indicated by his name and his writing is more or less personal [8].

Forgery is the fabrication of a fake written document or the altering of a real one with the goal to deceive.

It is not feasible to simulate everything perfectly. The forger attempts to replicate the form, size, style, slant and other general qualities of real signatures while mimicking them. To complete this assignment, he must remember the visual qualities of real signatures and be able to reproduce them on paper in a comparable manner. To duplicate the precise sameness of the general appearance of letters, all imitations require meticulous attention. And when the deed is performed, the speed slows and it takes longer to reproduce the original writing.

**Types of forgery**

For the purposes of identifying and comparing signatures and writings, forgeries are classed as follows:

- Simulated/Copied forgery/Memory forgery
- Traced forgery
- Freehand forgery (forgery without the use of a model or mimicry)
- Replacing revenue stamps with real signatures
- Erasures and alterations to documents [9].

**Simulated forgery:** It's a spoof or parody of real writing. The approach used in this class of forgery creation is the same as that used by students in copying. The kind of writing comprehension is entirely dependent on the examiner's ability to identify it according to its forgery class (Figure 12).


**Figure 12.** Types of forgeries in questioned documents. Note: A) Genuine signature, (B) Simulated signature.

The crime must be committed in complete secrecy, with the collaboration of time, situation and location. The history of crimes plainly shows that in the majority of cases, the perpetrator is a novice with no expertise who makes no particular preparations for a task without realising how tough it is.

**Traced forgery:** The Trace Forgery Name denotes an attempt to convert an exact copy of real writing to counterfeit document using some tracing procedure.

Traced forgeries show more hesitation, an abnormal change in direction, inconsistency of pen pressure and unnatural movement interruptions than simulation, but this is dependent on the scientific process of tracing used and the operator's skill (Figure 13).


**Figure 13.** Above samples showing traced forgery.

Typically, the perpetrator's major effort is on making the forged signature look close to the genuine one, for which he deems the process of tracing to be the greatest strategy compared to other forgery techniques.

**Freehand forgery:** Forgery without the use of a model, often known as impersonator forgery. When a person just uses the signature in its regular or modified form, portraying himself to be that person with an ulterior goal, such a signature is a fake.

When the real signature of an actual person is accessible, the forgery is clear and proving the same is not as tough in such circumstances. In this form of forgery, no attempt is being made; a model signature is not being utilised for the counterfeit; the signature is simply signed by freehand (Figure 14).

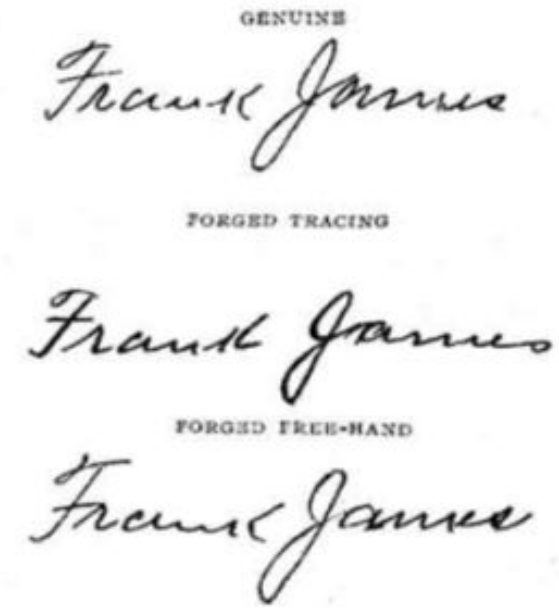


**Figure 14.** Displaying freehand forgery comparison with other types of forgeries.

**Replacing revenue stamps with real signatures:** Genuine signatures are used by transplanting revenue stamps retaining the original, genuine signature. The legitimate signature stamp is extracted from another document and placed to the desired paper.

**Erasures and alterations to documents:** Any document can be altered using erasure. It could be a way of erasing rectification, like rubbing, scraping or wiping out. A will or a section of a will may be

effectively revoked when the phrase "erasure" is used (Figure 15).

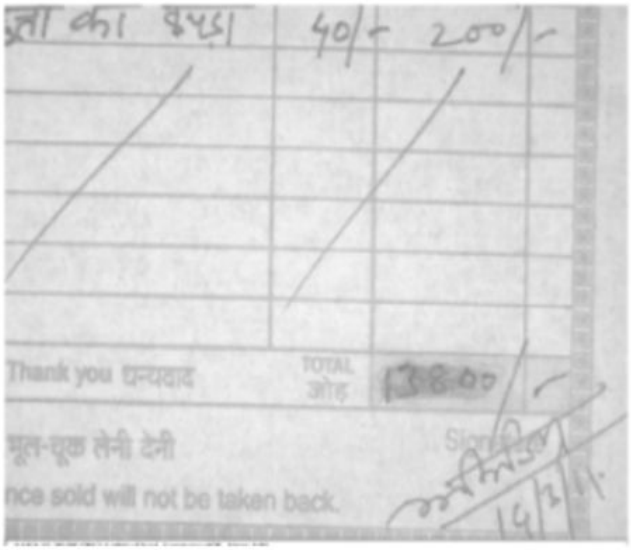


**Figure 15.** Obliterated figures visible under floodlight.

**Indicator of forgery**

- Starts and pauses are abrupt
- Lifted pens and hesitancy
- Pressure and speed
- Patching
- Tremor
- Tracing
- Shaky writing
- Sign of retouching
- Multiple pen stops
- Disturbed natural variation

**Starts and pauses are abrupt:** The forger touches the paper with the pen point before beginning to write. He pauses the pen and removes it off the paper once he has completed writing the name or a portion of it. This can result in a very sharp beginning or end where the pen made contact with the surface. There are occasions when this contact is maintained for such a long period that, if the pen has fluid ink, the ink will wet the paper and migrate away from the point of contact or even through to the paper's back. At the start and conclusion of names or letters, his leaves a tapering impression. Of course, there are several exceptions to this.

**Lifted pens and hesitancy:** This happens when the pen stops writing in an unexpected place in the paper, perhaps just before a significant change in direction or new letter formation is about to start. It can appear that there is a tiny gap when none was intended in the written line or that there is an overlap of pen lines where there should only be a single line of ink.

**Pressure and speed:** Again, because the pen moves slowly rather than dynamically as in most authentic writings, the ink line thickness remains constant, owing to the same steady pressure placed on a slowly moving pen. Internal lines will be tapered very slightly, if at all.

**Tracing:** Traced forgeries are often produced using one of three techniques: "transmitted light, carbon intermediate and pressure indented image." While tracings may not ordinarily constitute a significant barrier to the document examiner attempting to prove authenticity, the ability to identify the culprit is completely ruled out. Tracing another's signature or even handwriting, is the most effective form of disguise.

The questioned signature must have been created using tracing if the model and it agree completely. Even from the same individual, no two signatures or writings are ever completely identical. In addition, complete agreement between two, three or more questioned signs is sufficient tracing evidence. Of course, the document examiner must take caution that the template signature (genuine signature) isn't one of the signs in dispute when there is complete agreement between a number of signatures [10].

## Law of ACE-V

In order to determine the origins of the evidence, several forensic disciplines compare the evidence with well-known objects. Analysis, Comparison, Evaluation and Verification (ACE-V) is a comparative technique that is employed in a variety of forensic disciplines. The ACE-V procedure provides a framework for the examiner to use as they carefully compare the evidence [11].

**Analysis:** Analysis of questioned documents for example routine and dictated signature.

- Analysis of feature
- Specific marks analysis
- Style analysis
- Termination strokes analysis
- Punctuation analysis
- Elements of style
- Line ending
- Spacing

**Comparison:** Compare all the feature in question documents and signature was written in analysis. These all the feature helpful for the comparison between questioned and routine or dictated comparison. Forensic scientist compares the significant features in documents such as matched or unmatched features, size and speed comparison, slant comparison, variation in documents.

**Evaluation:** Now, the examiner evaluated all the features and evaluate if the document is forged or not. After the evaluation the forensic scientist accessed to the final result of particular questioned document

**Verification:** If an identification is made, a different examiner must confirm the result. This phase ensures the approach is applied objectively and verifies the first technician's findings. The adequacy of analysis made during the analytical phase may also be checked by the second examiner.

## Conclusion

In this paper, we use the Video Spectral Comparator 6000 (VSC) and ESDA to detect forgeries in documents. VSC is a highly useful technique in document inspection since it allows an examiner to analyze ink, disclose document modifications and see secret security features in money, passports and so on determining the chronological sequence of crossing strokes, improving writing on burnt papers and so forth.

Before operation, the VSC is turned on for the first time and the appropriate settings are made. In the VSC chamber, paper money is placed on a document platen beneath a canopy, which also holds a video camera, reflected light sources and optical filters. A video image is then shown on a monitor. You may adjust the placement of the money by observing the display. Once the currency note has been put, multiple lighting options in the UV (200-400 nm), Visible (400-700 nm) and IR (700-1000 nm) wavelength ranges, illumination geometries, various optical filters and various magnifications are used to get the desired results. When the intended output is achieved, the image is saved.

The Electrostatic Detection Apparatus (ESDA) is a device that detects indentation impressions on questioned papers. This study examines some of the known variables that influence ESDA findings, as well as others that have yet to be addressed. Investigating the influence of diverse levels of indentation on different paper qualities with different pressure of ball point, pen or pencil was one of the variables under investigation. This article also discussed the recognition of fake signatures and identity traits.

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