

Visualisation of Secret Handwriting by Physical and Chemical Method

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Abstract

Secret handwriting is a written note or message that is hidden and written with the help of invisible ink. There is a long history of using invisible ink for secret writing for various purposes. The practise involves writing information using fluids that are hardly visible under normal light. Invisible ink used as writing instruments makes the written message invisible to the reader, thus a visualisation or development technique is required to make the message visible. In this paper we are going to visualise the secret handwriting with both physical and chemical methods that is heat, UV, phenolphthalein and silver nitrate respectively.

There's a lot of physical as well as chemical methods to develop or visualise secret writing, that has been written by using the biological fluids (saliva, milk, tears), chemical fluid (vinegar, saline, baking soda), fruit or vegetables (garlic, ginger, onion, tomatoes, grapes, lemon), secret writing can be developed with the help of UV light, iodine fuming method, candle flame, oven, pH indicators, silver nitrate, phenolphthalein, etc. After the development of handwriting, it's possible for the Forensic investigator to analyse the writing and identify the person behind it as every individual has individual handwriting characteristics which enables the identification of the suspect. Secret handwriting is most commonly used by the prisoners, criminals, drug dealers, terrorists, international spies, and intelligence departments.

Visualisation and development of secret writing is important as it plays significant role in identifying the suspect, and it helps to solve the crime through the analysis of the handwriting, verification of documents, historical document analysis.

Keywords: Secret handwriting, Secret ink, Physical method, Chemical method, Forensic significance, Forensic science, Handwriting.

INTRODUCTION

Handwriting

Handwriting is a method of communication that has been used for several years and is still commonly used today. Handwriting is a neuromuscular phenomenon whereby writing words and letters with the help of writing instruments such as a pen or a paper on writing surfaces requires the coordination of the brain, 40 muscles, 27 small bones. In simple words, handwriting is the art of writing letters and words by hand using a pen or pencil (writing instruments) on paper or another writing surface.

In order to identify handwriting, there are three fundamental principles: Even after sufficient time and practice, no two skilled writers can have handwriting that is identical; even with a single person, there are some irregularities that occur naturally in handwriting; no writer can reach a higher degree of proficiency.

In other words, we cannot expect a flawless form of handwriting even from an individual who knows about the fundamental skills of handwriting. Occasionally, significant handwritten messages are found during the investigation of various criminal cases, including kidnapping, suicide, murder, threatening, or terrorist actions, where the authentication and ownership of such messages play a vital role in solving the case.

The identification of handwriting acquires a significant role in legal proceedings when the authenticity of a signature is questioned. Even when the handwriting itself isn't questioned, the conditions under which it was written sometimes become extremely important. The experts are frequently called upon to provide answer to such questions as whether the writer's hand was forced or guided and whether changes were introduced after the completion of the document. One of the first steps in the investigation of a questioned or disputed writing is to find some authentic writing by the disputed writer that allows to make a comparison. Each person has distinctive handwriting style, whether it is everyday handwriting or their signature. Even identical twins who are genetically and physically similar do not have the same handwriting. Because each person's handwriting is unique and distinctive, it can be used to determine the writer of the document. The writing characteristics that experts use in determining authenticity assumes that each handwriting possess certain permanent characteristic features from which the given handwriting sample may differ. Handwriting experts makes use of the specific shape of letters, regular or irregular spacing between letters, and the slope of the letters as well as rhythmic repetition of what is written , or rhythm disturbance, the pressure on the paper, the average size of letters and the thickness of letters. The presence or absence of tremors, different kind of final strokes, as well as other characteristics of handwriting are also used by handwriting experts for identification of handwriting.

Secret handwriting

Secret handwriting is a form of writing that is intended to make it challenging or nearly impossible for anyone other than the intended recipient to comprehend what is written. Secret handwriting is the act of writing with an objective of concealing the written message with a special ink that is invisible as long as exposed to a specific chemical or light source. In order to use invisible ink, ink needs to be prepared first and then applied to the writing surface.

This can be done using a variety of instruments, including a brush, pen with no ink, or even a toothpick. The message is written on paper or another appropriate surfaces, and caution is taken to ensure that the writing is not detectable under typical lighting conditions. To make the invisible ink message visible, certain physical techniques or chemicals are applied to the writing surface. The approach employed is determined by the kind of invisible ink used to write secret writings. The frequently used revealing techniques are heat, chemical reagents, UV light, etc. Heating the writing surface slowly over time, often using a heat source like a candle flame or oven, for example, exposing tomato juice to heat are capable of leaving traces of visible brown mark on the writing surfaces.

Applying certain chemical substances or reagents to the writing surface leads to reaction with the invisible ink, making the message visible. Using a UV light source, such as a UV chamber, reveals messages written with UV-reactive inks, under UV light the invisible ink will fluoresce or emit visible light making the message visible and readable. Secret handwriting, as already mentioned above, is a method of writing that enables the message to remain concealed or invisible until it is exposed to a specific physical technique or chemical. It has been used throughout history for wide range of purposes, including sending hidden messages, protecting confidential information, the exchange of entertaining or secretive communication,

or by criminals as well as investigators to deliver their message secretly. It can be used for other purposes as well, such as keeping a diary or writing personal letters.

History of secret ink

The first known usage of invisible ink for secret handwriting dates back to ancient times, in the 4th century BCE, by the Greek historian Thucydides. According to his account, the ancient Greeks used a solution of vinegar and water to inscribe secret messages on wood, which would only become visible after being exposed to fire or heat. During the Renaissance period, Leonardo da Vinci, an intellectual and inventor, used a combination of milk and lemon juice as invisible ink that could only be revealed by heating the paper. Other Renaissance writers and intellectuals, such as Giambattista della Porta, also carried out experiments with various fluids as invisible ink, including urine and onion juice.

Secret writing has been used since the middle of the 20th century to conceal messages, it was a means of communication for the prisoner; they used their saliva, sweat, and occasionally urine as invisible ink to write the message. These secret writings were also used by the government during times of war, like during World War I and II, invisible ink was used with the help of spies to communicate secretly and obtain exclusive information, and it became a common form of covert operations and communication among spies. They used secret inks like lemon juice, urine, and even semen to communicate and send secret messages. In that era, magnifying glasses and direct light were used to identify the hidden message, but later on, many more new approaches, including both physical and chemical methods, were introduced.

In modern times, invisible ink continues to be used for a variety of purposes, including security and verification. It is commonly used in the printing of sensitive documents, including banknotes and passports, where a special ink that can only be revealed under specific conditions is used in order to prevent counterfeiting.

Secret ink

Inks that aren't seen by the naked eye are also referred to as secret inks, mystery inks, sympathetic inks, or protection inks. They are used to deliver mysterious or confidential messages. Secret ink is a sort of ink that is intended to be invisible when applied to paper or other writing surfaces but can be revealed afterwards using a specific method or substance. Secret ink has been used for several centuries as a way to convey messages that are meant to be kept concealed from others. Criminals and spies typically used juices, which include lemon juice, orange juice, and various citric juices, since citric juices contain susceptible citric acid, which makes paper fibres vulnerable, when those paper fibres are exposed to heat, the fibres of paper on which citric juice was applied will turn brown unexpectedly since the citric acid found in citric juice, which weakened the paper fibres, whereas fibres on which citric juice wasn't applied will take longer time to turn brown and as a result this secret writing, turns visible. The most basic invisible ink experiment involves writing on a piece of blank white paper after dipping a brush in vegetable juice, biological fluids, and various chemicals. When the ink dries, it will be invisible to the naked eye, but if the paper is held up to a relatively low heat source such as a light bulb, a radiator, an iron, a lighter, or a burner and a UV lamp invisible writing can be visualised.

Forensic significance of the development of secret ink

The development and analysis of secret ink have forensic significance in various investigations. The forensic significance of secret ink is highlighted below:

Anonymous communication: In order to communicate anonymous messages or threats, secret ink is often used as means of communication, where hidden messages are written using substances that are hardly visible or identifiable. These hidden messages might be significant in criminal investigations, like in espionage cases, or cases involving the exchange of sensitive information. Forensic analysis of secret handwriting by comparing the handwriting characteristics with known samples of a specific person can help investigators link these messages to potential suspects.

Authenticity and verification: Secret handwriting can be used to verify the authorship of a document or a signature. Forensic experts can analyze documents suspected of containing secret ink to confirm the authenticity of the hidden message. They can detect the presence of secret ink and determine whether the message is authentic or has been altered through specialized techniques, such as ultraviolet (UV) light examination, infrared (IR) analysis, or chemical reagents. Forensic document examiners analyse various features of handwriting, such as strokes, spacing, size, letter formations, slants, pressure, and other individual characteristics, to determine whether secret handwriting matches with the known handwriting of a specific individual.

Criminal investigations: In criminal cases, secret handwriting may be detect on numerous items, such as graffiti, forged documents, ransom notes or extortion letters. The analysis of secret ink can help establish a connection between suspects and specific documents. Forensic document examiners can determine the involvement of suspect or rule them out by comparing the secret handwriting with known samples of suspects.

Historical document analysis: Throughout history secret ink has been used for variety of purposes, such as military communication, intelligence operations, confidential activities. Forensic analysis of secret ink in historical documents can provide insights into the events of past and hidden messages, or shed light on secret operations from various time periods.

REVIEW LITERATURE

Secret writing has played a vital role in human communication as it allows individuals to convey messages secretly, protect confidential information, and engage in secret operations. Secret writing, also known as “mysterious messages”, has an interesting and long history that can be traced back to ancient times. This literature review aims to provide a thorough overview of the secret writing techniques.

Deepti Andharmule, Neeti Kapoor, and Ashish Badiye did research on “An Evaluation of Some Commonly Used Methods for Visualisation of Secret Writing” in 2013, and this paper is meant to serve as a scientific introduction to secret writing for those unfamiliar with the subject. This research paper consists of 27 samples that contained concealed messages written using biological fluids, chemical fluids, and vegetable fluids. After a regular interval of five days, they were then visualized using physical methods such as UV lamps, heat treatment, and chemical methods in a specific time interval, from the 1st day to the 30th day. According to this paper, the most effective method for visualizing a secret message with biological, vegetable, and chemical fluids is heat and iodine fuming.

Lee J, Kong SG, Kang TY, Kim B, Jeon OY did research on “Invisible Ink mark Detection in the Visible Spectrum using Absorption Difference” in 2014 and this paper provides an image processing technique, in order to expose invisible ink patterns in the visible spectrum without the use of specialised equipment like UV lights or IR filters. Colour dispersion or absorption difference is caused by a very thin layer of printed invisible ink patterns that possess a different refractive index for each wavelength of light. In order to determine invisible ink patterns on the surface, the suggested approach determines the difference in

colour components brought on by an absorption differential. The outcomes of the experiment indicate the effectiveness of the suggested approach for both IR- as well as UV-active invisible materials.

Sushma Upadhyay and Farheen Fatima did research on the topic “Simple Techniques to Reveal Invisible Ink in Forensic Science” in 2017, and this paper discusses secret writing that can be revealed by heating and its significance in forensic science. This research paper comprises ten samples in which secret messages are written using invisible ink such as vegetable juice, fruit juice, and biological fluids, and then they are revealed through physical and chemical methods, which will enable one to specify and identify the secret message. Secret writing written with fruit juice turned brown when heated. Chemical fluids under a UV lamp fluoresce blue. Secret writing written with vegetable fluids visualized with the help of a heat source was visible in brown. Secret writing written with vegetable fluid, when placed beneath a UV lamp, was visible as blue fluorescence. The heating method is most effective for revealing secret writing on paper.

Hussain SS, Sahu M, and corresponding author Manju Sahu conducted research in the year, 2017, on the topic “A Study on Common Visualisation Methods for Secret Writing done by Invisible Inks and Their Sensitivity Over a Period of Time”, where this research paper primarily focuses on the use of invisible inks. This research study consists of secret writing samples to study the common visualization techniques for secret writing done by invisible inks and to find out the sensitivity of these methods over a period of time, which contain hidden messages written using some fruit juices, chemical fluids, and biological fluids. They were then visualized using conventional physical and chemical methods in a specific time interval; they were examined from the 1st day to the 30th day, following a regular interval of five days. The most effective physical and chemical techniques for visualizing secret ink were heating and iodine fuming, respectively. Both of these methods showed positive results for up to a month.

Chen FF, Zhu YJ, Zhang QQ, Yang RL, Qin DD, Xiong ZC conducted research on the topic “Secret Paper with Vinegar as an Invisible Security Ink and Fire as a Decryption Key for Information Protection”, in the year 2019 and in this paper they have discussed about a new sort of ultralong, network-structured hydroxyapatite nanowire and cellulose-based secret paper has been produced. White vinegar, a common cooking ingredient, was used to produce invisible security ink. Different pens loaded with white vinegar can be used to write in numerous ways on secret paper. Since fire has a short reaction time, concealed information on the secret paper written with white vinegar that is completely invisible in natural light can be deciphered and read clearly upon being exposed to fire.

METHODOLOGY

Aim

To visualise the secret writing with the help of different physical and chemical method.

Material required

UV lamp, paper, painting brush, candle, phenolphthalein reagent, oven, silver nitrate solution, biological fluid, chemical fluid, fruit and vegetable fluids.

Samples

This paper includes forty samples of secret writing, that is used as a concealed message in the form of invisible ink such as fruit juice (grapes), vegetable juice (lemon, ginger, garlic, tomatoes, onion), chemical fluids (saline water, baking soda), and biological fluids (saliva, milk), and then they are visualised using physical and chemical methods.

Secret writing samples were prepared on A4-size blank papers, and a painting brush was used as a writing instrument. The brush was dipped in the appropriate invisible ink, and messages were written on the blank white paper. The papers with secret messages were marked at the bottom with the name of the invisible ink used. The papers containing written messages were kept under a running fan so that the inks dried up and the writings became invisible. These samples were then kept at room temperature. After that, they were analysed using various physical methods (heating them up and visualizations under an ultraviolet chamber) and chemical methods (treatment with phenolphthalein solution, and treatment with silver nitrate solution).

Visualisation

The visualisation techniques include both physical and chemical techniques, as mentioned above. Physical methods rely on external factors, such as heat or light, to enable a response from the ink, making it visible. However, chemical methods involve a chemical reaction between the secret ink and specific reagents or solvents to reveal the secret message.

Physical method

Physical methods primarily depend on physical changes caused by heat or light to make the secret ink visible. The heat may change color or shade, while UV light may cause fluorescence. While some of the physical visualisation/decipherment techniques are destructive in nature, the majority of the physical methods are non-destructive in nature such as UV. Primarily, visualisation by physical methods is preferred; however, some physical methods may have limitations on the sort of secret ink they can reveal as different secret inks may require specific physical conditions in order to be visible, and if the physical method fails, then the chemical method tends to be preferred.

Ultra-violet light: It is a non-destructive technique. The use of a UV chamber for the detection of secret ink is helpful since most of the invisible inks give off fluorescence when viewed under UV light. Place the paper in an ultraviolet (UV) chamber; the fluorescence makes the impressions of writing visible, the sample must be photographed if the writing is visible.

Heat: Heat is frequently used to reveal hidden messages written with the help of secret inks as it's convenient method. There are various methods of revealing the invisible ink by heat, including placing the paper in the oven, holding the paper up to a hot light bulb, keeping the paper near the candle flame, and ironing the paper. These developing methods aid in revealing the message through the change in color that is caused by the thinning of the paper.

Chemical method

Chemical methods involve chemical reactions with the secret ink, modifying its properties and making them apparent or visible. If physical decipherment of secret writing fails, then a few chemical methods can be applied for the development of secret writing. Though most chemical methods are destructive in nature, chemical methods offer greater adaptability as specific reagents or solvents can be selected based on the kind of secret ink, allowing for a greater number of possible visualisation outcomes.

Silver Nitrate: Due to the presence of specific salts, various invisible inks react with silver nitrate when treated. Silver salts are formed due to the reaction between salts and silver nitrate. When exposed to light, these silver salts degrade into silver metal, thus producing color and making the message visible.

Phenolphthalein: It is a destructive technique of decipherment. Phenolphthalein is a chemical that is frequently used as an indicator for acid and base. Depending on the pH of the solution it is in, it changes color. In acidic or neutral solutions, phenolphthalein is colorless but changes to pink or magenta in the

presence of bases. A secret message can be revealed due to the color change caused by applying phenolphthalein to the surface.

RESULT

Secret writing samples written with various biological, fruits and chemical fluids were visualised by physical (heat and UV) and chemical methods (phenolphthalein and silver nitrate).

Visualisation of secret ink by heating

Secret writings written with fruit juices, chemicals, and bodily fluids turned brown when heated. This is due to the nature of these fluids, which are either slightly acidic or alkaline, which weakens the paper. After the water has evaporated and the paper has dried, the acid or base from these fluids remains in the paper. When the paper was placed at a heat source, such as an oven, these acidic or alkaline parts of the paper turned brown more quickly than the rest of the paper, thus revealing the message written on the paper.

Visualisation of secret writing under UV chamber

Due to their fluorescence, or the uneven absorption and emission of UV rays by them, fruit juice and biological fluids like lemon, grapes, tomato, ginger, garlic, and milk were visible under UV light. The concealed message or secret writing appeared and became easily readable or visible because it fluoresced when UV-reactive ink was subjected to the UV radiation generated by the chamber's UV lights.

The visibility and clarity of the message are also affected by various factors, such as the concentration of the ultra violet reactive ink, the size and quality of the ink, and the time and intensity of exposure to the UV light.

Visualisation of secret writing using phenolphthalein solution

Applying the phenolphthalein solution carefully to the piece of paper containing the secret writing helps reveal the concealed message. The secret writing, written using a basic solution like detergent and baking soda, was visible after applying phenolphthalein solution to the surface, as the base interacts with the phenolphthalein and turns pink.

Some of the invisible inks appeared transparent when treated with phenolphthalein solutions, as phenolphthalein is colorless in acidic or neutral solutions. Another possibility may be that slightly acidic fluids thin or weaken the paper at places where they are applied, making those parts of the paper wetter than other portions of the paper and hence appear transparent when introduced to phenolphthalein solution.

Visualisation of secret ink using silver nitrate solution

Certain types of salt, as we know, interact with silver nitrate to form silver salt that converts to silver metal when subjected to light, and this metallic silver reveals a brown color.

As the silver nitrate solution reacts with the milk, the hidden message will start to become apparent. Milk contains proteins and fats, which react with silver nitrate in order to produce a brownish-black color. This reaction takes place due to the reaction between the milk protein and the silver ions present in silver nitrate. However, the intensity of the color may differ according to the milk and the concentration of silver nitrate used.

As the silver nitrate solution reacts with the garlic juice, it results in the appearance of the hidden message. This occurs as a result of a chemical reaction between the silver nitrate and the organic compounds present in the garlic juice, which results in the formation of silver compounds. These compounds can include silver sulphide (Ag_2S) and silver oxide (Ag_2O). The color that appeared after the reaction of garlic with AgNO_3 was brownish-black.

Observation table

Table 1: Result of visualization of fruit juice, chemical and biological fluid through physical and chemical methods

Samples	Heat	UV chamber	Phenolphthalein	Silver nitrate
Milk	+	+	-	+
Detergent	+	-	+	-
Lemon	+	+	-	-
Grapes	+	+	-	-
Saliva	+	-	-	-
Tomato	+	+	-	-
Ginger	+	+	-	-
Baking soda	+	-	+	-
Saline water	+	-	-	-
Garlic	+	+	-	+

Conclusion

The visualization of secret ink through physical and chemical methods plays a vital role in national security, law enforcement, historical research, document validation, and personal understanding. These techniques make it possible to explore hidden information. Secret writing samples can be visualised by both physical and chemical methods. All the methods produce various results with different chemical compounds.

Among all the physical methods mentioned, development by heat is the most effective. Even though it's a destructive technique, it gives results with almost any kind of invisible ink. However, this approach to visualise does not take much time, and the visibility seems to be excellent. Visualisation under UV light is also an excellent technique, as it is a non- destructive method and gives a positive result most of the time. Ink developed by heat mostly gave a brown color, while inks visualised under UV light fluoresced blue.

While among chemical methods, silver nitrate and phenolphthalein produce satisfactory outcomes, both of these techniques are destructive. Silver nitrate may be effective if the secret ink contains salt solutions or chloride ions or is reactive with them. Phenolphthalein is primarily used as an acid-base indicator and may reveal secret inks that are basic in nature. When phenolphthalein interacts with a base, it changes from colorless to pink, giving an obvious indication that a base-based secret ink is present. It is useful for revealing secret inks made up of basic liquids like baking soda and detergent.

The most effective method between silver nitrate and phenolphthalein depends on the specific characteristics of the secret ink being analysed. If the properties of the secret ink, whether it contains chloride ions or is basic, if the ink used are known, it enables one to choose the appropriate chemical method. However, if the properties of the secret ink are unknown, one needs to analyze both solutions to determine which one gives the most favorable outcome.

In conclusion, of the four methods used, heating and UV are the best visualisation and development methods for secret inks.

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