Dr. Mieczyslaw Goc
Vice-President of the Polish Forensic Association
An expert in the field of document examination PTK
Eng. Marek Miron
Director of the Forensic Laboratory of the Polish Forensic Association
An expert of physical chemistry PTK

Examination of the relative age of documents. Part I Methods of examining the sequence of writing made using different techniques on a paper substrate – general issues

Summary

Determining the chronology of writing is essential in cases of suspected document forgery by addition, adding to the content of a finished document, backdating, and also in the case of the use of documents signed in blank, and is one of the most difficult problems in the forensic document examination. The results obtained so far, using a variety of examination methods, do not allow for unambiguous decisions. This applies both to simple microscopic methods, diffusion techniques and methods using more advanced technologies (such as Raman spectroscopy, electrostatic examination, scanning and confocal microscopy). The research problem is referred to in the literature and forensics as the determination of document "relative age".

The article is an introduction to a series of publications presenting the results of the research carried out within the framework of a development project, a joint venture of the Department of Forensic Science, the University of Warsaw (UW) and the Polish Forensic Association (PTK). The aim of the project was to develop methods for testing the relative age of the writing made by various techniques on a paper substrate, including non-intersecting.

Keywords document, writing age, absolute age, relative age, chronology of writing, sequence determination of writing, intersecting lines, non-intersecting lines, diffusion, optical methods, 3D, Raman spectroscopy

Introduction

Determining the age of a document or its components can relate to the preparation time appearing on the document, in the absence of a date or claims as to its authenticity, it is then defined as an investigation into the absolute age or the absolute age of the document [1, p. 773]. The examination of the age of writing can be performed using graphical and physicochemical analyses methods.

Graphical methods consist in determining the likely time of creation of the examined writing, most often signatures, on the basis of their graphical features, based on the assumption that the writing, in addition to its durable features, with a high level of stability, also includes certain features affected by modifications over the years. This kind of analyses, however, requires extensive research material prepared under different conditions that would allow the exclusion of other factors (mental and physical condition of the writer, circumstances in which the examined writing was prepared, the type of writing tools used, the substrate, etc.) as a source of possible graphical fluctuation. Often, the level of stability of graphic forms, particularly of signatures, is so significant that it does not give rise to inference of the time of creation, or vice versa, the studied writing is characterized by these options of graphical solutions which do not allow them to be linked to the time of creation of the writing being examined. These difficulties mean that such a method of determining the age of writing, especially when it comes to ranges of a few, or even more than ten years, including the period of stabilizing the document, during which there were no affects of illness, trauma or other factors dramatically affecting the psycho motor performance of the writer and the appearance of the writing, so the results of graphical analyses are generally highly hypothetical.

Physicochemical methods require specialized equipment (GC/MS), and in Poland are performed in a few laboratory facilities (Central Forensic Laboratory of the Police, Department of Chemistry, University of Wrocław, Department of Forensic Science, Polish Forensic Association). Examining the age of a document is based on measuring the decay of a strong volatile solvent (2-phenoxyethanol) commonly occurring as a constituent of ballpoint inks. This methodis based on the work of V. Agiński of

1996. It has been verified by experts from the Central Forensic Laboratory of the Headquarters of the Police and the result of their work was published in "Problemy Kryminalistyki" in 2002. The usefulness of this method has been positively rated by the work of Agiński [2, p. 18–16]. However, it has many limitations, such as the inability to indicate a precise time of writing. It can only determine whether the traces of ink on the questioned document are fresh, that is, deposited over 18 or more years from the date of the examination (in practice, this dividing line is too fuzzy and in most cases extends over several months). Moreover, this method requires removing small samples of the writing substrate from the questioned document, in the place where the ink was deposited. As such action violates the integrity of the questioned document, this method is destructive in character. Also, the received results generally are not of a conclusive nature.

However, the investigative and legal aims concerned with examining questioned documents are often not to determine a specific time a text or signature was created but to determine whether all the writing appearing on the document were created at the same time and in what order they were made on the surface of the document. For practical reasons, the previous question, limited to writing occurring on paper surfaces, is the subject of a series of publications; the first of these is this article. These publications will present the results of extensive research carried out in the framework of a development project implemented jointly by the University of Warsaw and the Polish Forensic Association[1]. These studies address issues that in the literature of the subject are referred to as marking the relative age of the document [3, p. 51; 1, p. 773].

Methods for determining the chronology of intersecting and non-intersecting lines on a paper substrate

Determining the sequence of writing made on paper surfaces is one of the most difficult problems in forensic document examination. From the practise of experts and results presented by national and international publications, it is shown that results obtained using various methods of examination are unclear and inspire controversy [4–6]. This applies both to simple methods of microscopic diffusion techniques and methods that use more advanced technologies (such as Raman spectroscopy, electrostatic examination, electron microscopy and confocal microscope).

Determination of the chronology of writing is essential in cases of suspected document forgery by addition. These are particularly difficult issues of investigation in terms of evidence, especially in the case of documents signed in blank. As a rule, they also relate to the counterfeiting of documents confirming the fictional existence of very large, often multimillion sums (bills, liabilities, receipts, wills, etc.), and as such, these crimes carry a particularly heavy burden of social harm. Counterfeiting of this kind can rely on the preparation of a document using an earlier signature made in blank with additions to the content of the finished document, backdating, and so forth [3, p. 51].

In practice, the forensic examination of questioned documents in such cases involves the following issues:

- examination of the sequence of intersecting texts,
- examination of the sequence of non-overlapping texts (non-intersecting).

These issues have also become the subject of experimental examination carried out in the framework of the aforementioned development project of UW and PTK, the aim of which was to develop an effective method of testing both intersecting lines and non-overlapping texts (non-intersecting) on paper substrates, made using a variety of writing and printing methods. Currently used for this purpose are primarily methods based upon visual inspection of the line intersections. However, the results obtained by help of a stereoscopic microscope do not always give satisfactory results and the ability to make conclusive decisions. This depends on many factors related to the technique of writing: the type of paper substrate, its class, colour, type of writing implement (pencil, fountain pen, ballpoint pen, etc.) and of the writing medium (graphite, ink, india ink, gel ballpoint ink, pigment, etc.) technique of writing (force, tilt of the writing implement, hardness and smoothness of the surface under the paper). A simple-to-use method is to remove intersecting lines of writing using fingerprint film or other similar materials, such as Kromekote paper. From experiments and the descriptions of the results of these methods, it is shown that in the process of transferring crossing ballpoint lines, upper line is transferred, which is the one which is later drawn [1, p. 779–780]. A variation of this method is diffusion copying, which involves moistening the text, e.g. with ethanol and pyridine, and transferring it onto a white or colourless fingerprint film, and then evaluating whether the intersection of the lines is broken. This is illustrated in Figure 1 (Diffusion copy – image of a signature with a visible gap at the intersection of a signature stroke through a line of print; see Polish version), where the arrow indicates a break in the continuity of the signature stroke at the intersection of the line of printing, which proves the latter applied to the second. In this case, a signature has probably been used in blank or applied to another document.

These methods can be effective in determining the sequence of intersecting lines, prepared with similar writing instruments and inks, which is difficult when using only optical methods. Sometimes, it might be helpful to use UV and IR radiation taking advantage of luminescence (Fig. 2 Image of a signature and

intersection of a line of print visualized using IR luminescence; see Polish version). While the use of the possibilities offered by Adobe Photoshop, using among others, gradient maps for image processing to determine the order of overlapping lines, is preferable to illustrate previously made findings using other methods rather than as an independent method for determining the chronology of writing on a substrate (Fig. 3 Image of a signature and the intersection with a printed line visualized using gradient maps in Adobe Photoshop; Fig. 4 Signature image and the intersection of lines visualized using diffusion copying and gradient mapping in Adobe Photoshop with a visible gap at the intersection of the signature stroke through a line of print; for both see Polish version).

In the eighties, electrostatic methods began to be used in the examination of documents in forensic laboratories, e.g. using an ESDA device to reveal transparent invisible impressions caused by the pressure of a writing instrument on a substrate (Fig. 5 ESDA device, being used to reveal mechanical impressions (helpful in determining the sequence of intersecting lines; see Polish version). As is clear from scientific reports, this technique can be helpful in determining the sequence of intersecting graphic lines, and thus in determining the relative time of their creation[2]. Experimental studies performed in the PTK laboratory of documents examination have demonstrated the usefulness of this technique in a very limited way.

There are also reports of promising results of Raman spectroscopy in the examination of intersecting lines[3]. Raman spectroscopy is a measurement technique widely used in physics and chemistry to identify chemical substances, as well as to provide measurements of their physical properties. This method is based on the analysis of the Raman spectrum recorded by the spectrometer. An inherent element of Raman spectra is the spectrum of light of a substance, or photoluminescence. It is a non-destructive method and thus can be especially useful in the examination of forensic evidence, including the determination of the sequence of intersecting and non-intersecting lines made using different techniques on a paper substrate (Fig. 6 Raman spectrometer which is used in the laboratory of document examination of the Polish Forensic Association for studying intersecting and non-intersecting; Fig. 7 Microscopic image of toner particles on a line of text visualized using a Senterra raman spectrometer from the Brucker company; Fig. 8 Raman spectra of toner and gel-pen ink; see Polish version). Details of the technique and the possibility of its use for the evaluation of the order of overlapping lines will be presented in the next article in a series of publications devoted to issues of examining the relative age of documents.

For the determination of the sequence of intersecting lines of text, a video spectral comparator (VSC) also be used, which enables the performance of fluorescent scans and analysis of absorptive and reflective spectra (reflectance). Comparing the spectra chart from the area of intersecting lines of text from the spectra charts for inks, which co-create the examined writing, may be helpful in formulating conclusions regarding their sequence[4] (Fig. 9 VSC 6000 video spectral comparator in the document examination laboratory of the Polish Forensic Association was used to examine intersecting lines; see Polish version). Experimental studies conducted in the document examination laboratory of PTK, confirmed the usefulness of this device, but mainly in the possibilities offered by the observation of line impressions in angular lighting, as well as using infrared luminescence on the negative image, while using functions of spectroscopy could show no conclusive results.

A very expensive and, in expert practice, seldom used method of determining the order of overlapping records is using a scanning electron microscope[5].

Another method recently used in forensic laboratories to examine the sequencing of texts, both intersecting and non-intersecting, is 3D technology. This method requires the application of a high-quality scientific microscope, capable of obtaining large magnifications of the scanned objects (from 100 to 1000 times) and visualizing them in 3D (Fig. 10 Research position in the laboratory of document examination of the Polish Forensic Association enabling observation of objects in a 3D technique; Fig. 11 Crossing of a line of writing visualized in a hundred-fold magnification in 3D; see Polish version). This system makes it much easier to determine sequence of overlapping writing using the same and different inks and techniques (manuscripts, prints, stamps, prints, and so forth). Thanks to an adequately large magnifications of brightness and sharpness of the images, the 3D technique can also be applied to determine the sequence of non-intersecting texts. This applies to cases where it is necessary to determine whether the signature (writing) on a questioned document containing a text printed using a captured thermal fixed image (laser print, xerographic copy) has been applied to the document before or after printing.

Evaluation of the shape, colour, gloss, location and other structural properties of both the line of writing alone and the toner particles occurring within it, after standardizing characteristic features on the basis of experimental samples, it turns out, in combination with other methods, very useful in taking final decisions on the locational order of lines and print[6].

Summary

Considering both difficulty from the research point of view and that of document examination, which is to assess the chronology of writing using a variety of

inks and techniques as well as due to inconsistent evaluations of the efficiency of these methods, presented in the literature and reports of expert practice, there were carried out, within the framework of the aforementioned development project of UW and PTK, comprehensive examinations and tests to verify the possibility of testing the described methods. Above all, however, it focuses on working out more precise methods of indicating the sequence of texts, taking advantage of upgraded optical microscopy, which makes use of software to observe objects in 3D, as well as by using Raman microscopy. Technological development, especially in the field of computer software, combined with possibilities offered by modern microscopy, optics, 3D technique and Raman spectroscopy, allow for significant progress in this field of document examination and make possible to give opinions on matters which have so far remained outside the sphere of procedural knowledge. The reliability of this type of forensic research depends largely on the possibility of verification of the results obtained by various analytical techniques. While the diagnostic value of the results is higher, the more discriminatory techniques are applied. It is advised to implement concurrent methods, which differ in their operating principles (e.g. verification of results by using techniques based on spectroscopy). A more detailed description of these methods and the results of their use to assess the sequence of texts made by a variety of writing instruments and inks on paper will be the subject of subsequent articles prepared by a group of authors involved in the implementation of the aforementioned research project.

Source

Figs. 1–11: authors

Translation *Ronald Scott Henderson*

Notes

[1] These issues have become the subject of a development project entitled: "Development of a methodology and construction of a position to study the chronology of writing made with different techniques and inks on a paper substrate" which was a joint scientific and research project carried out by the University of Warsaw and the Research and Training Centre of the Polish Forensic Association. The project was funded by the Ministry of Science and Higher Education (Contract no. 0019/R/T00/2010/11 dated 26/08/2010 on the implementation of the development project 0R00 0038 07 concluded between the Ministry of Science and Higher Education and the Consortium UW and CBS PTK). The project lasted 24 months, starting from 26/08/2010, the project manager was Prof. Dr. Tadeusz Tomaszewski, and the scientific and executive team comprised: Prof. Dr. Ewa Gruza, Dr. Mieczyslaw Goc, Eng. Marek Miron and M.S. Maciej Broniarz. The study was also attended by experts from the Central Forensic Laboratory of the Police, who, among other things, prepared control tests and the Forensic Bureau ISA, which on the basis of the consent of the Head of the Internal Security Agency joined the experimental part of the project including, inter alia, the use of confocal microscopy to assess changes in the line crossings of writing after being subjected to thermal impact by a laser printing device.

[2] E. Fabiańska: Postęp w badaniach pisma ręcznego i dokumentów, [w:] Postępy w naukach sądowych, wyd. Instytutu Ekspertyz Sądowych, Kraków 2009, s. 200–201.

[3] E. Fabiańska, M. Kunicki: Raman spectroscopy as a new technique for determining the sequence of intersecting graphic lines, "Z zagadnień nauk sądowych" 2006, no. 67, p. 252; T. Widła, B. Zawisza: Examination of intersecting lines using Raman spectroscopy (case study), Technical and forensic studies of the authenticity of public documents, Materials 6. Conference, Poznań 26–27 September 2007, H. Kołeckiego, Poznań Publishers, Poznań 2009, p. 133–135. In the latter publication, the authors, citing the results of experimental tests carried out at the Institute of Forensic Research, indicate the need for cautious evaluation of the effectiveness of the Raman technique in determining the sequence of overlapping lines.

[4] Ibid, p. 134.

[5] On the effectiveness of this technique for determining the relative age of questioned documents indicates, inter alia, B. Hołyst, see B. Hołyst: Kryminalistyka, op.cit. p. 779.

[6] As part of the above mentioned development project, in the laboratory of PTK examination documents, an extensive research using 3D techniques was conducted. The tests were performed using a Nikon Eclipse 80i microscope equipped with a motorized Z-axis drive, a digital camera, a SCHOTT KL 1500 LCD illuminator (optional) and NIS Elements Nikon AR/EDF software. It allows getting a thousandfold magnification, automated, sequential (layered) scanning of an object in the Z axis, of high resolution and depth, as well as its visualization in 3D. This system can be used to evaluate the sequence of texts, both intersecting and non-overlapping. The details of the topic will be presented in the next article of this series.