этом исследовании изучалось влияние эмоций обвиняемого, выраженных в походке и отображаемых на видеозаписи, на принятие решений коллегией присяжными. Видеозапись ходящего мужчины, изображающая одну из четырех эмоций (гнев, страх, счастье или гордость) или нейтральное эмоциональное состояние, была представлена 100 псевдо-присяжным вместе с контекстной информацией. Их попросили определить, какие эмоции, по их мнению, изображает ходячий, и их уверенность в этом отождествлении. Степень эмпатии и суждения псевдо-присяжных по делу оценивались с помощью анкеты. Результаты исследования показывают, что эмоции, которые изображает фигура на фрагменте видеозаписи, могут быть идентифицированы наблюдателями. Кроме того, результаты показывают, что эта информация неявно используется наблюдателями для обоснования сочувствия и суждений. Однако результаты также предполагают вариабельность в способности наблюдателей точно описывать полученную информацию. Поэтому необходимо внимательно рассмотреть возможные последствия воспроизведения видеозаписи в суде и последующее влияние на принятие решения коллегией присяжных.

Ключевые слова: походка, восприятие эмоций, принятие решения коллегией присяжных.

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OPTICAL PROFILOMETRY AS A METHOD FOR DETECTING INDENTED WRITING

The current methodology for indented writing detection involves electrostatic detection apparatus (ESDA) processing and oblique light. While commonly used in forensics analysis, ESDA has several drawbacks, including its unsuitability for documents of certain shapes and densities, the damage it occasionally causes to evidence, its need for prior humidification in order to process documents, and the ozone it creates. In this study we evaluated optical profilometry as an alternative to ESDA. We tested several optical profilometer brands and showed their capacity for *detecting very slight indentations, even to the magnitude of 8µm. We also obtained the clear resolution of a 3D image of this writing.*

***Key words:** forensic science, indented writing, optical profilometer, questioned document examination.*

Introduction. When sheets of paper are in direct or indirect contact with each other, writing on the top sheet can produce indented writing on the sheets below. The current standard procedure for examining documents for indented writing is to first view the documents with oblique light. If indentations are not observed, the documents are then examined using electrostatic detection apparatus (ESDA) [1].

ESDA is commonly assumed to be a straightforward, non-destructive technique suitable for the examination of any kind of document, but this assumption has been proven untrue. Several factors including size, shape, density, and condition make a document unsuitable for the ESDA procedure. Cardboard, books, and large file folders are just a few examples of documents for which ESDA is less useful. Furthermore, when examining a stack of paper, the capacity of ESDA to detect indented writing drops drastically for each layer beneath the top sheet.

But even when a document is suitable for evaluation by ESDA, optimization of the procedure is challenging. For example, optimal detection of latent pressure patterns of writing requires humidification of the document to a high level of humidity (60 %< RH) [2].

Another concern is that contrary to common belief, the ESDA process may damage the exhibits under certain circumstances. When processing documents that contain original pencil writing, a small amount of the pencil writing is sometimes transferred from the paper to the back of the polymer film that is used in the ESDA process [3], thus destroying the evidence.

Finally, it has been discovered that the use of ESDA creates ozone [4], which can cause respiratory irritation and breathing difficulty. Continuous use of ESDA can generate ozone concentrations that will exceed the permissible exposure limit mandated by the Occupational Safety and Health Administration. Along with ozone from the corona, produced during the development process, toner particles are released into the environment, especially when using the Cascade Developer method, which is considered qualitatively better than other methods [5]. These health concerns encouraged a company named Attestor Forensics to develop the Toner Particulate and Ozone Reduction System TORnado SF91 to reduce these dangers [5; 6].

Due to all the concerns mentioned above, there has long been the need to develop an alternative method for the examination of indented writing [7].

Unlike ESDA, optical profilometry is an absolutely non-destructive method because it uses light to obtain surface morphology, step heights and surface roughness. It can be done on a single point, as a line scan or even a full three-dimensional scan. Optical profilometry was already successfully demonstrated in 2006 for a different purpose of questioned documents examination, that of determining the sequence of homogenous crossing lines [8].

This paper evaluates the use of profilometry as a non-destructive method for the detection of indented writing, focusing on the capacity of profilometry to detect discreet indentations beyond what is currently possible.

Experimental. A survey of optical profilometers was conducted to preliminarily examine the technology's potential for the detection of indented writing. Several companies were approached to conduct a proof-of-concept experiment demonstrating the capabilities of their profilometers. Due to the broad nature of this study, it was impossible to completely standardize the protocol, and participating companies were enabled to perform their own variation of the experiment using different equipment settings. However, the main experimental parameters were the same. Each company created a mark or a writing with a pen on a pile of papers, then examined the layers beneath the written page with their optical profilometer. All tested profilometers are listed in Table 1.

Table 1.

The tested profilometers

#	Model and brand
1	**Bruker ContourLS-K 3D**
2	**Bruker Contour GT**
3	**Sensofar S-neox**
4	**Novacam Technologies Inc. Microcam-3D, 2-Axis Profilometer**
5	**Zygo ZeGage**
6	**Zygo NewView**
7	**Nanovea HS2000 3D Profilometer**
8	**Zygo ZeGage Pro HR**

Results and discussion.

1. Bruker ContourLS-K 3D

The Bruker ContourLS-K 3D experiment was run on a sample consisting of four layers of standard white printer paper, with a dot on the top page that was drawn with a ballpoint pen. Every layer – the top page and the 3 subsequent layers – was scanned with the optical profilometer using an objective of 10x. The experiment setup can be seen on Fig. 1.

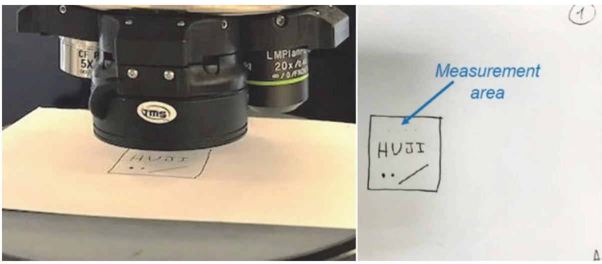


Fig. 1. Bruker ContourLS-K 3D with the dots that were used for the experiment

On each page, a 3D topographical image of the indented dot was analyzed, with a height profile given for the X and Y axes. The recorded heights of the indented dot were 91µm, 53µm, 34µm, and 21µm for the top page, second page, third page, and bottom page, respectively. In Fig. 2, the analysis for the top page is shown.

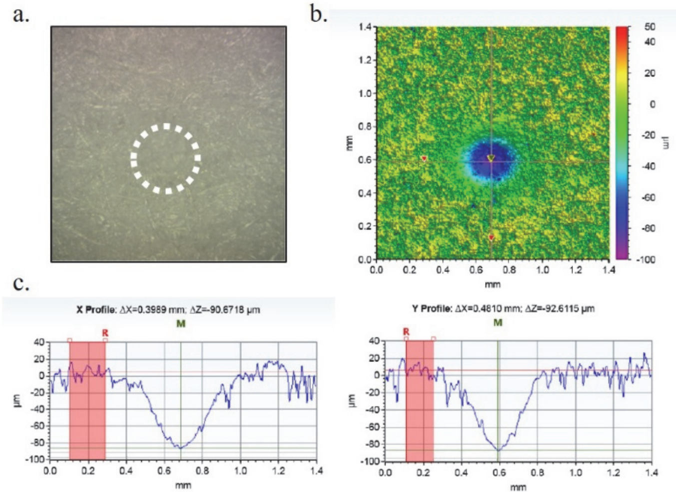


Fig. 2. Analysis of the top page: a. a microscope enlargement photo of the area hat was tested; b. 3D topographical image of the indented dot; c. a height profile for the X and Y axes

Evolving deformation can clearly be seen, with the deformation depth ecreasing with each successive layer (Fig. 3).

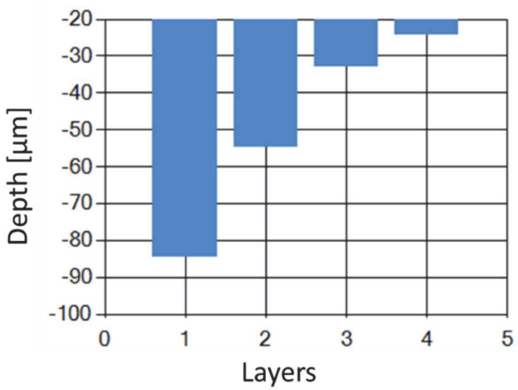


Fig. 3. Depth versus # layers

2. Bruker Contour GT (Performed at the The Hebrew University Center for Nanoscience and Nanotechnology)

The Bruker Contour GT experiment was run on a pangram (Fig. 4) written on a 9x9cm white memo block page. The sample text was created with a blue ballpoint pen. The top five layers of paper under the sample text were examined.

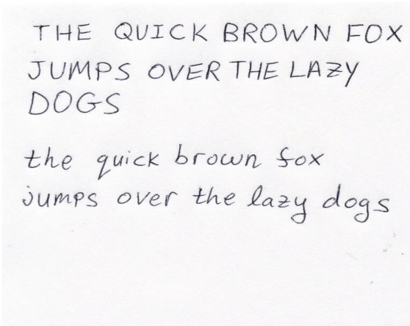


Fig. 4. Sample text

Results could be retrieved only from the first layer under the sample text. A nonuniform topographic map of the sentence was obtained, with some letters more readable than others (Fig. 5).

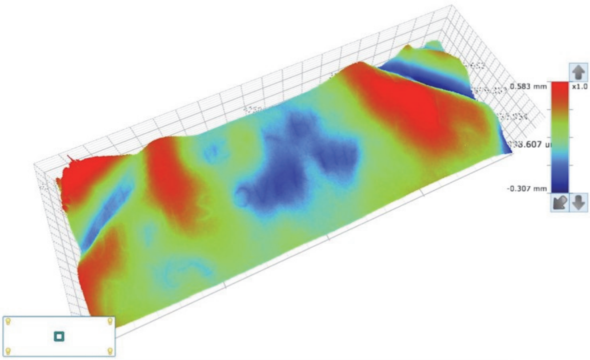


Fig. 5. A topographic map of the sentence

3. Sensofar S-neox

For the Sensofar S-neox experiment, text was written with a blue ballpoint pen on paper. The first layer beneath the written page was taken for analysis, and the area directly under the tip of the letter “f” (blue square) was examined (Fig. 6).

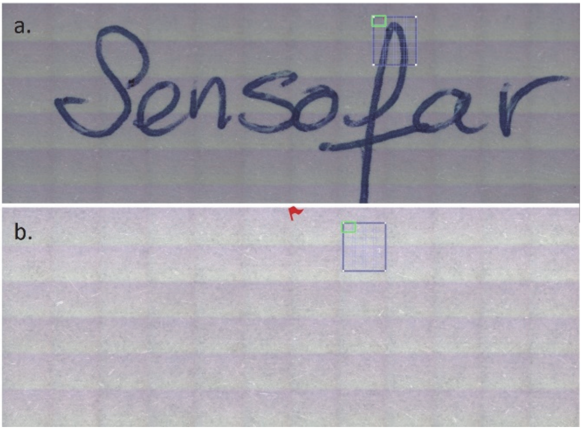


Fig. 6. Sensofar S-neox, the area that was examined is marked by a blue square, a. the written page; b. the first layer beneath the written page

Scanning with the optical profilometer produced 2D and 3D topographic pictures of this letter, as can be seen in the figures below (Fig. 7-8). Moreover, it was determined that the height profile could be recorded for any point of the layer. It is important to stress that the depth (ΔZ) of the indentation (in relation to the paper surface) recorded here was from the order of 8µm.

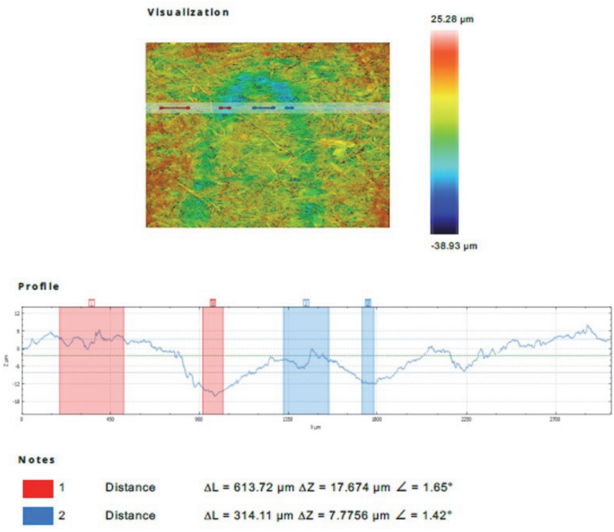


Fig. 7. 2D topographic picture of the letter with its height profile

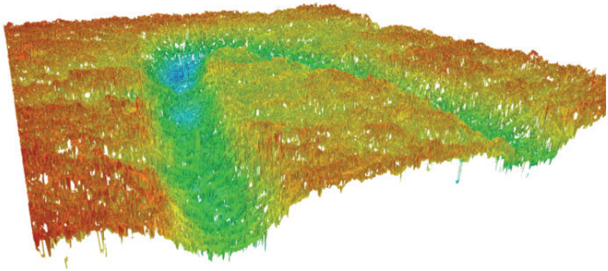


Fig. 8. 3D topographic picture of the letter

4. Novacam Technologies Inc Microcam-3D, 2-Axis Profilometer

For the Novacam Technologies Inc Microcam-3D, 2-Axis profilometer experiment, the words "Hi ARIEL" were written on a multi-layered stack of papers. Scanning resulted in a good quality 3D topographic picture for the first layer beneath the written page, as can be seen in Fig. 9). Indentations are in the order of 20µm.

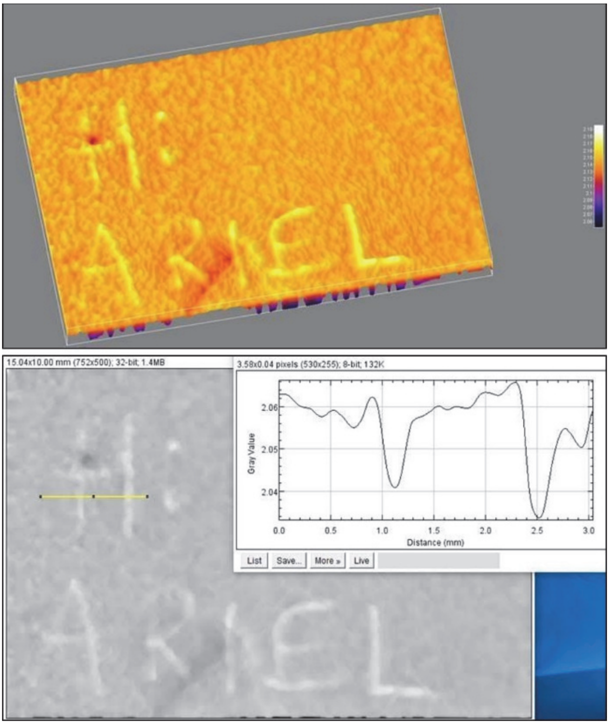


Fig. 9. 3D topographic picture of the words with a height profile

Zygo ZeGage

The Zygo ZeGage experimental sample consisted of the word "ZYGO" written with "natural" pressure.

All measurements were taken with a ZeGage™ Plus with normal resolution and 1024x1024 @ 100Hz camera mode. The tool was configured with a 2.75x Michelson objective, 4.5 mm working distance, 3.01x3.01mm field of view, and 2.940μm lateral resolution. 3xCSI mode was used for measurement.

The best results in this experiment were received with the paper stretched tight and taped to flat metal mount as shown in Fig. 10.

Fig. 10. Paper stretched tight and taped to flat metal mount

A good quality 3D topographic picture was produced from the first layer beneath the written page even under "natural" pressure, though the description of the pressure was not objectively measured but only evaluated by the feeling of the writer (Fig. 11-12).

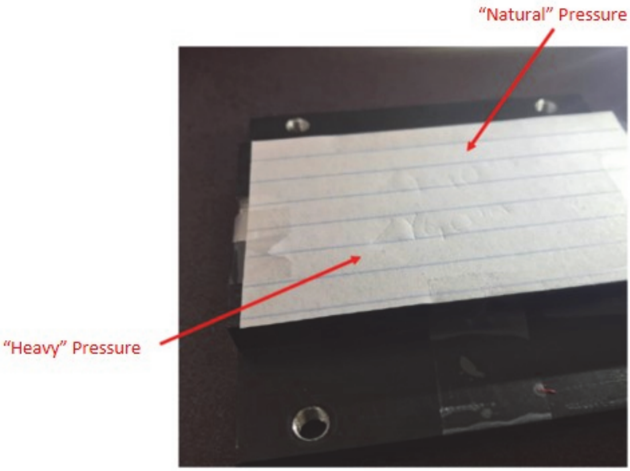


Fig. 11. The evaluated paper with arrows indicating "natural" and "heavy" pressure

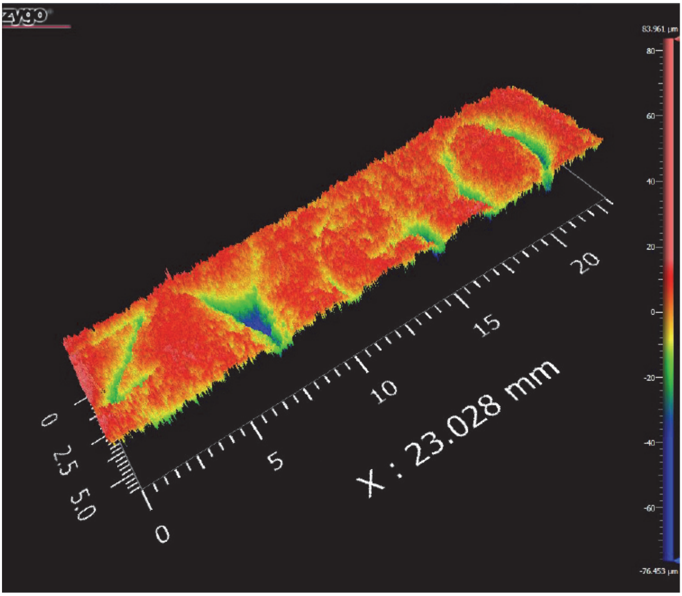


Fig. 12. 3D topographic picture of “Zygo” written in natural pressure

5. Zygo NewView

The Zygo NewView experiment examined a sample on which the Hebrew word “משטרה” (=police) was written.

A clear 2D/3D topographic image was produced from the first layer beneath the written page, and the height profile can be seen in (Fig. 13). The depth of the indentations is from the order of 14µm.

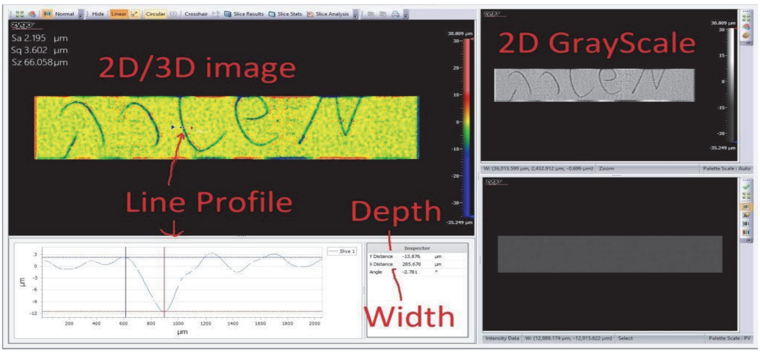


Fig. 13. 2D/3D topographic image and height profile

6. Nanovea HS2000 3D Profilometer

The Nanovea HS2000 3D profilometer experiment was done on a sample with the word “Nanovea” written using different applied pressures.

A clear 2D/3D topographic image and a height profile was produced from the first layer beneath the written page (Fig. 14). Fig. 15-17 show both decreasing max depth and readability with the lowering of applied pressure. A feature called “slices analysis” (shown in Fig. 18) enabled selection of the desired height range for visualization, thus eliminating the masking effects of over-layers of writing and other indentations.

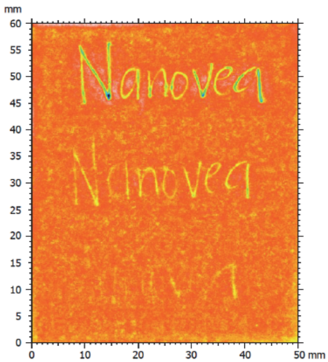
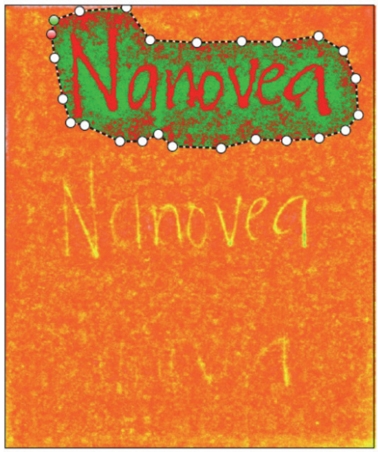
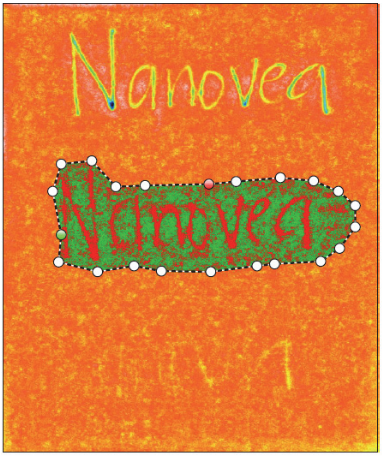


Fig. 14. False color view showing the height profile of the indented writing



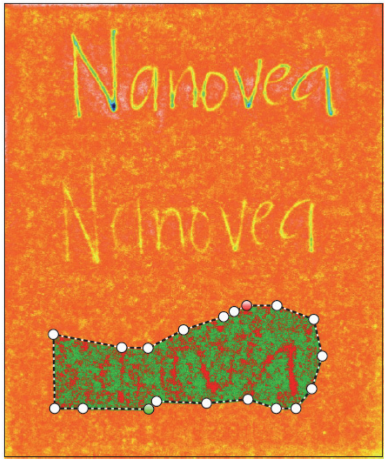
Parameters	Unit	Hole
Surface	mm²	193
Volume	µm³	1459560315
Max. depth/height	µm	77.9
Mean depth/height	µm	7.55

Fig. 15. A complete analysis showing the maximum depth of a specific word compared to the mean depth of its surroundings for the writing with the highest pressure



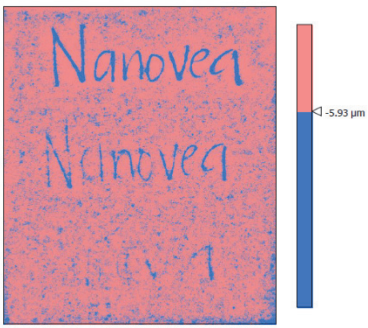
Parameters	Unit	Hole
Surface	mm²	150
Volume	µm³	752750679
Max. depth/height	µm	72.0
Mean depth/height	µm	5.01

Fig. 16. A complete analysis showing the maximum depth of a specific word compared to the mean depth of its surroundings for the writing with the intermediate pressure.



Parameters	Unit	Hole
Surface	mm²	107
Volume	µm³	426521068
Max. depth/height	µm	49.7
Mean depth/height	µm	3.98

Fig. 17. A complete analysis showing the maximum depth of a specific word compared to the mean depth of its surroundings for the writing with the lowest pressure



Parameters	Unit	■ (blue)	■ (pink)
Projected area	%	14.9	85.1
Volume of void	%	1.01	82.2
Volume of material	%	99.0	17.8
Volume of void	µm³/mm²	726363	26617312
Volume of material	µm³/mm²	71393252	5766513
Mean thickness of void	µm	0.726	26.6
Mean thickness of material	µm	71.4	5.77

Fig. 18. Slices analysis

Summary and conclusions

Through this research, we have demonstrated the capacity of optical profilometry for the detection and deciphering of indented writing for forensics casework. Trials were run on several types of optical profilometers, and all were able to detect indented writing to some extent. Specific achievements of the tested optical profilometers include the detection of single dots on even the third page under the original writing paper, along with the detection and decipherment of writing of a magnitude as small as 8μm and the clear resolution of a 3D image of this same writing. Not only were these results encouraging, but the translation of the indentation topography into numerical values as provided by the profilometer suggests a tremendous benefit for computational processing of the collected data. The usefulness of these types of measurements and formatting for computational integration is only beginning to be understood.

Considering the compelling proof of concept achieved in this research, we believe optical profilometry has much to offer the field of documentation analysis, and that it is worthwhile to continue along this line of work to a more extensive investigation.

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ОПТИЧНА ПРОФІЛОМЕТРІЯ ЯК МЕТОД ВИЯВЛЕННЯ РЕЛЬЄФНО-ТИСНЕНИХ НАПИСІВ

А. Ельяшів
С. Візнер

Поточна методологія виявлення рельєфно-тиснених написів включає в себе обробку пристроєм електростатичного виявлення (ESDA) і вивчення у косопадаючому світлі. Хоча ESDA широко використовується в криміналістичному аналізі, він має кілька недоліків, в тому числі його непридатність для використання з документами певної форми і щільності, збиток, який він іноді завдає доказам, вимагає зволоження документів для їх обробки і озон, який він створює.

У цьому дослідженні ми оцінили оптичну профілометрію як потенційну альтернативу ESDA. Були проведені випробування оптичних профілометрів декількох марок, і всі вони в тій чи іншій мірі змогли виявити рельєфне тиснення. Деякі з помітних досягнень протестованих оптичних профілометрів включають виявлення окремих точок аж до третьої сторінки під оригінальним папером, дешифрування написів розміром всього 8 мкм і чітке розширення тривимірного зображення цього ж напису. Ці результати не тільки обнадіюють, але перетворення топографії вдавлення в числові значення, що надаються профілометри, дають величезну перевагу для обчислювальної обробки зібраних даних. Корисність цих типів вимірювань і форматування для обчислювальної інтеграції тільки починається.

Беручи до уваги переконливі докази концепції, досягнуті в цьому дослідженні, ми вважаємо, що оптична профілометрія може багато чого запропонувати в області аналізу документації, і що варто продовжити цю роботу для більш ширшого дослідження. Наступний етап включатиме в себе ретельне порівняння характеристик обробки ESDA і оптичної профілометрії.

Ключові слова: криміналістика, рельєфно-тиснене написання, оптичний профілометр, технічна експертиза документів.

ОПТИЧЕСКАЯ ПРОФИЛОМЕТРИЯ КАК МЕТОД ОБНАРУЖЕНИЯ РЕЛЬЕФНО-ТИСНЕННЫХ НАДПИСЕЙ

А. Эльяшив
С. Визнер

Текущая методология обнаружения рельефно-тисненных надписей включает в себя обработку устройством электростатического обнаружения (ESDA) и изучения в косо-падающем свете. Хотя ESDA широко используется в криминалистическом анализе, он имеет несколько недостатков, в том числе его непригодность для использования с документами определенной формы и плотности, ущерб, который он иногда наносит доказательствам, требует увлажнения документов для их обработки и озон, который он создает.

В этом исследовании мы оценили оптическую профилометрию как потенциальную альтернативу ESDA. Были проведены испытания оптических профилометров нескольких марок, и все они в той или иной степени смогли обнаружить рельефное тиснение. Некоторые из заметных достижений протестированных оптических профилометров включают обнаружение отдельных точек вплоть до третьей страницы под оригинальной бумагой, дешифрование надписей размером всего 8 мкм и четкое разрешение трехмерного изображения этого же написания. Эти результаты не только обнадеживают, но преобразование топографии вдавливания в числовые значения, предоставляемые профилометром, дает огромное преимущество для вычислительной обработки собранных данных. Полезность этих типов измерений и форматирования для вычислительной интеграции только начинается.

Принимая во внимание убедительные доказательства концепции, достигнутые в этом исследовании, мы считаем, что оптическая профилометрия может многое предложить в области анализа документации, и что стоит продолжить эту работу для более широкого исследования. Следующий этап будет включать в себя тщательное сравнение характеристик обработки ESDA и оптической профилометрии.

Ключевые слова: криминалистика, рельефно-тиснённое написание, оптический профилометр, техническая экспертиза документов.