جامعة نايف العربية للعلوم الأمنية
NAIF ARAB UNIVERSITY FOR SECURITY SCIENCES
تأسست ١٩٧٨ Est. 1978

Naif Arab University for Security Sciences
Arab Journal of Forensic Sciences and Forensic Medicine
المجلة العربية لعلوم الأدلة الجنائية والطب الشرعي
https://journals.nauss.edu.sa/index.php/AJFSFM

الجمعية العربية لعلوم الأدلة الجنائية والطب الشرعي
Arab Society for Forensic Sciences and Forensic Medicine

Measuring Line Length: A New Signature Feature in Forensic Examination

قياس طول مسارات الجرات المكونة للتوقيع: علامة مميّزة جديدة للتوقيع خلال الفحص الجنائي للخطوط

Ahmed Saad Gouhar[1]*, Paolo Vaccarone[2]
[1]Department of Forensic Sciences, College of Criminal Justice, Naif Arab University for Security Sciences, Riyadh, Saudi Arabia.
[2]Grafica Forense® Srls, Roma, Italy.

Received 10 Mar. 2024; Accepted 27 Apr. 2024; Available Online 18 Jun. 2024.

Abstract

The scientific methodology for forensic examination of handwriting is based on studying the individual handwriting features and characteristics that distinguish its writer from others.

The general qualities and the more detailed ones, some of which are "static" and refer to pictorical elements, while others refer to the pen's "dynamic" movement are investigated. Forensic handwriting experts during their daily activities are asked to analyse various features, many of which are suggested by the most prominent authors (connections, dimensions, proportions, shape, inclination, line quality, etc.), some of which are measurable, while others can only be inferred. However, the recent emergence of digitally captured signature (DCS) technology in the forensic field, has enabled the expert to analyse and evaluate new aspects, such as the length of the line. In the present study, an attempt has been made to study the line length and its possible uses in forensics handwriting examination processes. The authors, with different backgrounds and with different writing styles (Latin alphabet - Arabic alphabet), have tried to go further than the so far known study of handwriting for forensic purposes, studying and comparing the genuine lengths of the signature line and those that are forged (simulated).

Keywords: Forensic document examination, Forgery, Simulation, Natural variations, Writing characteristics, Digitally captured signatures, Biometric signatures, Electronic signatures.

المستخلص

تعتمد المنهجية العلمية للفحص الجنائي للخطوط اليدوية على دراسة المميزات والخصائص الخطية الفردية التي تميز كاتبها عن غيره.

يتم دراسة الخصائص الفردية والصفات العامة للخطوط وأكثرها تفصيلاً، حيث إن بعضها «ساكن» ويشير إلى عناصر تصويرية، وبعضها الآخر يشير إلى حركة القلم «الديناميكية». يُطلب من خبراء الكتابة اليدوية تحليل الميزات المختلفة للخطوط أثناء أنشطتهم اليومية، حيث يقترح مؤلفون بارزون العديد منها مثل: الارتباطات، الأبعاد، النسب، الشكل، الميل، جودة الخط، وما إلى ذلك، وبعضها قابل للقياس، في حين يمكن استنتاج الآخرين. ومع ذلك، فظهور التوقيع الملتقط رقميًا حديثًا (DCS) في المجال الجنائي، مكّن الخبير من تحليل وتقييم الجوانب الجديدة، مثل: طول مسارات الجرات المكونة للتوقيع. وفي هذه الدراسة، جرت محاولة لدراسة طول مسار الجرات واستخداماته المحتملة في عمليات فحص خط اليد في المجال الجنائي. لقد حاول المؤلفون، ذوو الخلفيات المختلفة وأساليب الكتابة المختلفة (الأبجدية اللاتينية - الأبجدية العربية)، الذهاب إلى أبعد من الدراسة المعروفة حتى الآن للكتابة اليدوية للأغراض الجنائية، حيث قاموا بدراسة ومقارنة الأطوال الحقيقية لمسارات جرات التوقيعات الصحيحة وتلك المقلدة.

الكلمات المفتاحية: فحص المستندات الجنائية، التزوير، المحاكاة، التغيرات الطبيعية، خصائص الكتابة، التوقيعات الملتقطة رقميًا، التوقيعات البيومترية، التوقيعات الإلكترونية.

Production and hosting by NAUSS

* Corresponding Author: Ahmed Gouhar
Email: agoher@nauss.edu.sa

doi: 10.26735/WXIF8532

1. Introduction

The global commercial marketplace increasingly involves the use of contract signatures, including between parties from different place in the world and backgrounds, by means of digital signatures. These certainly include digital signatures made using tablets, referred to in forensic fields as "Digitally Captured Signature" (DCS) [1]. DCS is widely referred to in a variety of terms, including biodynamic signature, biometric signature, digital handwritten signature, dynamic signature, handwritten electronic signature, and online signature [2].

This use of signing, besides being very practical and quick, is also very secure as the inserted signatures are connected to the document, most frequently in PDF format, through highly secure encryption processes to make, also, fraudulent transfer of a genuine signature to another document not possible.

The present study is the consequence of the difficulty, in measuring the perimeter of an irregular shape such as that created by a signature. This Feature has never been reported by examiners who have dealt with features related to the complexity of a signature [3-5]. The main difficulties and impediments that prevent the possibility of applying mathematical and geometric formulas to know the perimeter of an irregular shape, are connected to the fact that angles are not always present, a circumstance that would help the expert to divide the areas into several polygons or triangles to facilitate the calculation of the individual sides, since sometimes there are curved stretches alternating, without necessarily changing direction to create angles, with others that are more linear. A further variable that can make the work of calculation and measurement even more difficult is the impossibility of measuring the length of overlapping strokes as is the case of a signature.

One of the possible solutions hypothesised by the authors was to use software to measure the line length of a signature. The quickest method was to use dedicated and specific software useful for forensic analysis of DCS [6].

DCSs are graphical representations of a set of data captured by the combination of signature solutions. By signature solutions we mean the simultaneous interaction between hardware (tablet and pen) and software useful for capturing (i.e., this software only captures data and is not useful for analysing it from a forensic point of view) data on positioning (on XY Cartesian axes), on the speed of movement and sampling of the pen on the tablet, and on the pressure exerted on the tablet. By calculating the data of progressive pen placements on the tablet, information on the length of the signature line can also be easily and quickly obtained [7].

The authors then used other software (Regula® Forensic Studio) again for specific forensic use, to measure traditional pen-on-paper (P&P) signature lines. All these characteristics, being closely related to specific knowledge of only forensic handwriting experts (FHE) who know the reasons for their dynamic and not only static occurrence, must be studied, analysed, and evaluated by them even if they concern areas that could, erroneously, be assessed by Information Technologies (IT) experts.

The FHE studies the forensic handwriting variation and the connection, physical and neuromuscular between hand and pen.IT experts, differently, in the process of forensic analysis of a document, in fact, are called upon to make an opinion only with reference to the genuineness and non-alteration of the document, but not of the authenticity of signatures [8].

Figure 1- *Ten genuine signature to be forged in Latin style*

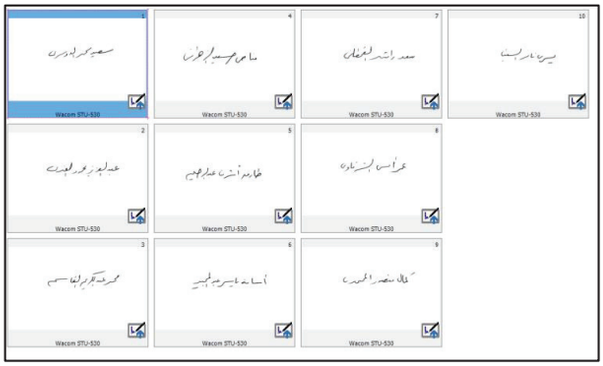


Figure 2- *Ten genuine signature to be forged in Arabic style*

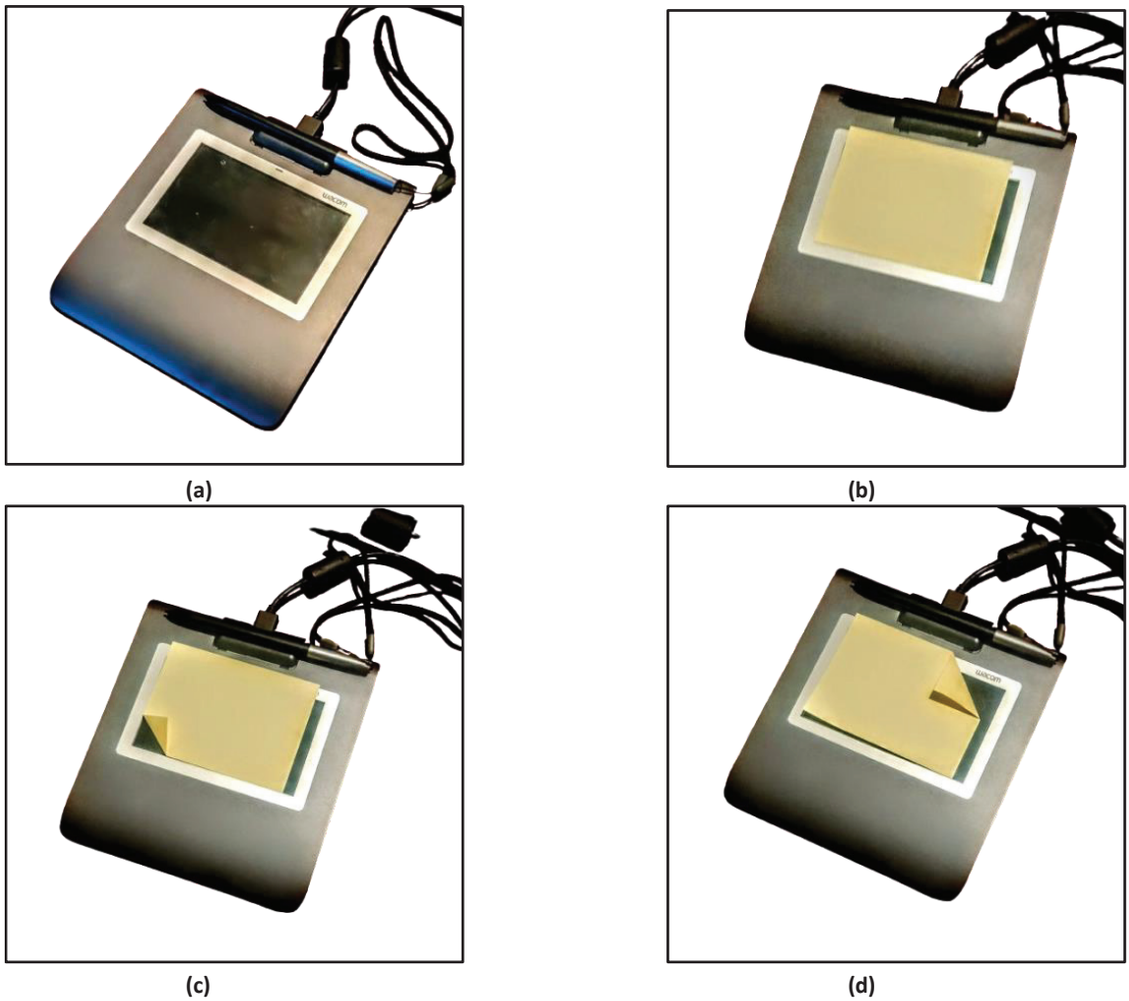


Figure 3- *(a): Wacom pad used to capture the signature, (b): Position of the post-it added over the active area, (c): Position on the bottom side of the active area, (d): Position of the glue part un the top of the active area*

2. Material and Method

The first step carried out by the authors was to prepare 10 genuine signatures with "hybrid" mode to be forged [4]. The second step was to submit participants to an anonymous questionnaire and a consent form. The questionnaire aimed to learn

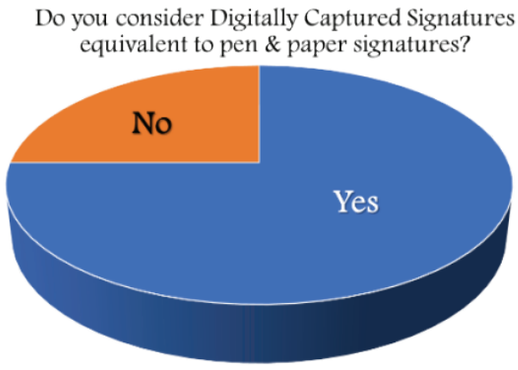
about "lay" peoples" perceptions of DCSs and the difficulty of reproducing the characteristics of signatures to be forged, age, level of schooling, language spoken, hand used, and confidence with DCS of the forgers.

After completing the survey, each participant was given the 10 signatures to be forged five times each.

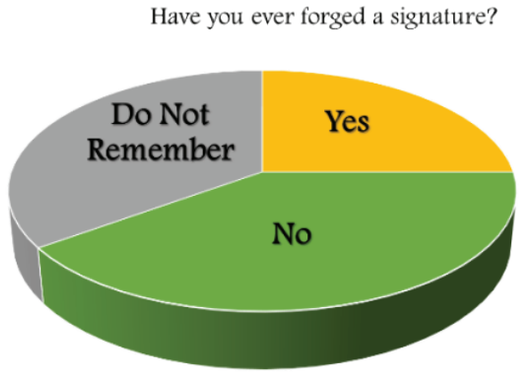
The signatures to be simulated were 10 made with Latin characters and 10 in Arabic with total number of 100 signatures. The authentic signatures and all the simulated ones were collected with the same DCS solution (Hardware: Wacom STU530 - Software: Namirial FirmaCerta Forensic) to have similar data that did not need to be subjected to a "normalization "procedure. The signatures, both authentic and simulated, were taken with the "hybrid" system (H-DCS) by placing a yellow post-it note over the active part of the signature pad (active area) and signing with the Bamboo "inking pen"[9].

The authors, therefore had at their disposal both the traditional version (pen and paper - "P&P") and the digitally captured version (DCS) of each signature, for a total of 1.000 signatures (500 "P&P" + 500 "DCS") simulated. In this way, all the biometric data, including the length of the visible line and the in air stroke (IATs) were captured and archived.

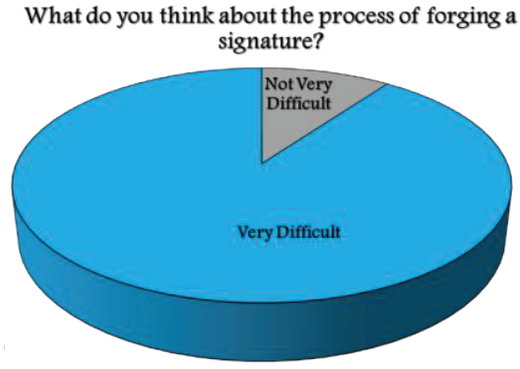
In a next step, signature line length was also studied and measured by Regula® Forensic Studio software and Regula 4177 digital microscope on P&P signatures. This procedure was aimed to have further confirmation of the reliability of the data



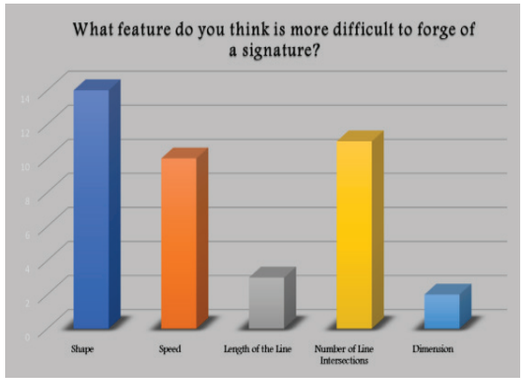
Question n. 1: *(Yes: 15 - No: 5)*



Question n. 2: *(Yes:5 - No:8 - Do Not Remember:7)*



Question n. 3: *(Very Difficult:18 - Not Very Difficult:2 - Very Easy:0 - Easy:0 - Imposible to Realyze:0)*



Question n. 4: *(Shape:14 - Speed:10 - Length of the Line:3 - Number of Line Intersection:11 - Dimension:2)*

digitally captured by the signature solution used (Namirial Firma Certa Forensic) and also to study whether “line length” can be reliably measured even in traditional signatures (P&P). In DCS, the software (Namirial Firma Certa Forensic) performs a 'metric' count of distances in the X-Y axis of the tablet's active area, measuring every 5 milliseconds, in P&P signature the measurement is performed using and converting image pixels by the software (Regula® Forensic Studio).

This circumstance is also useful for forensic comparisons between DCS and traditional signatures [10].

3. Results and Discussion

The first part of studying the captured data, involved the questionnaire submitted to the participants.

As can be seen in the images above, the results of the anonymous questionnaire submitted to the lay participants (the term “lay” refers to the circumstance that the participants were not forensic experts in handwriting analysis or DCS) were not always homogeneous and unambiguous.

In contrast to the first question, in which a prevalence of “yes” answers could be observed, in the second question, i.e. whether or not the participant interviewed had ever simulated a signature, the answers were relatively uniform across all three response possibilities given to the participants. Uniform was the response to the third question in which almost all participants answered that the process of forging a signature is "very difficult". In the fourth question, where it was asked which characteristic of a signature is most difficult to replicate and forge, the results were varied and unexpected for the authors.

In the various possibilities given, in fact, "length of the line" and "size" were the least difficult features for the interviewees to simulate. The "shape"was considered the most difficult to forge, and immediately afterwards the "number of line intersections" was considered. These results surprised the authors because the "number of line intersections" is considered by leading and established authors and forensic handwriting experts as one of the characteristics that allow the expert to evaluate and assign more or less "complexity" to the handwriting and signature. The "shape", in fact, is regarded by forensic experts as a static characteristic that can be reproduced, more or less easily, by the forger who focuses his/her attention on it.

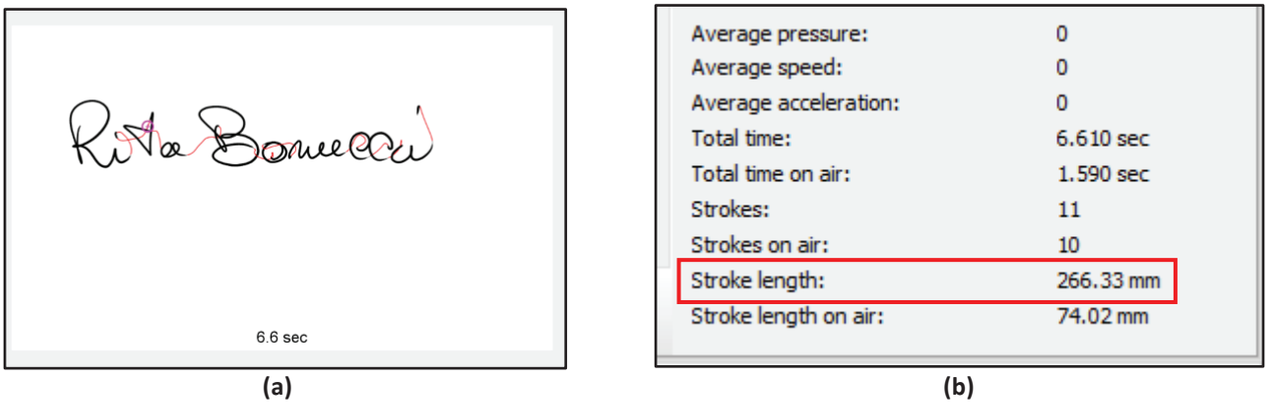


Figure 4- *Genuine signature - Latin style - (a):Visual feedback of DCS - (b): Some data captured during the realization of signature.*

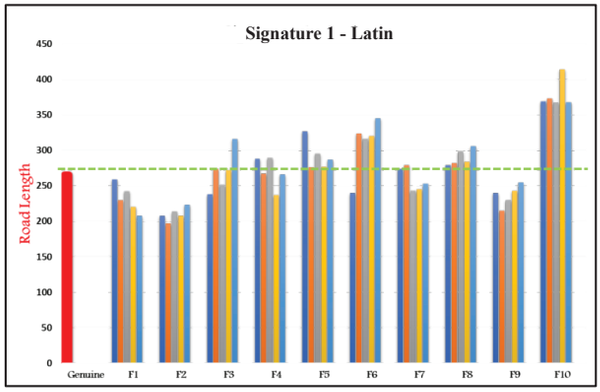


Figure 5- *Result of the all-forged signature compared to the genuine one - Latin style*

The first signatures compared were those in which the length of the line was considerable. Procedure followed for both Latin and Arabic alphabet signatures.

In the previous and following images (Figures 5 and 6), one can see how the line length data of the genuine signatures (left red line) was compared with the five forged signatures for each forger.

Already from the first comparisons, it could be seen that the "line length" correspondence depended very much on the individual skills of the forgers

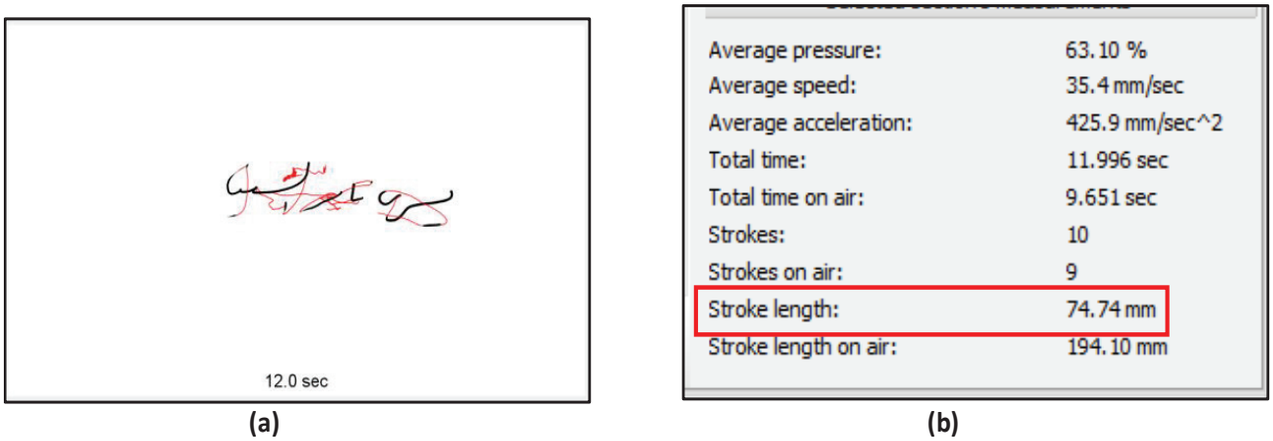


Figure 6- *Génuines Signature - Arabic style - (a): Visual feedback of DCS - (b): Some data captured during the realization of signature*

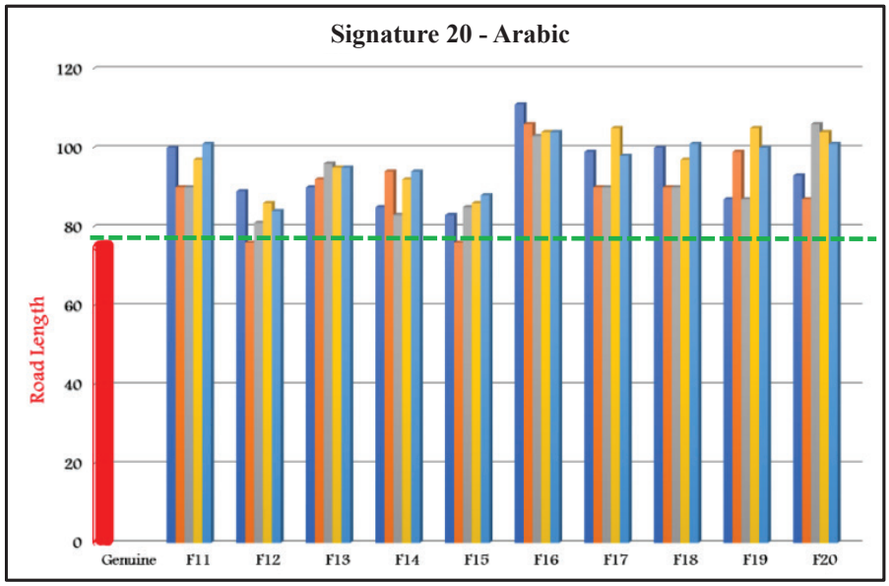


Figure 7- *Result of the all-forged signature compared to the genuine one - Arabic style*

("F" in the line below). It was also possible to note that although the forged signatures were made synchronously and sequentially, some forgers (F1, F3, F6 of the Latin alphabet signatures. Fig. 5) showed wide variability in making signatures of the same line length.

In comparisons of the genuine signatures (N=20) made with Arabic alphabet, it is possible to note that in two circumstances, in the opinion of the authors that happened by mere casualty, the forgers ("F12" and "F15") forged the signatures by making the line the same length as the genuine one. In all other cases the lines were consistently longer than the genuine ones.

Particularly important and relevant, are the data arising from comparisons between genuine and forged signatures made with a particularly short line (Signature 10 - Latin alphabet). In this comparison (Figure 9) it was possible to find that all forgers made forged signatures with particularly different line lengths than the genuine ones. This circumstance was also found to be at odds with the survey data submitted to forgers in which the data showed that “line length” was not considered to be a difficult characteristic to be forged and reproduced.

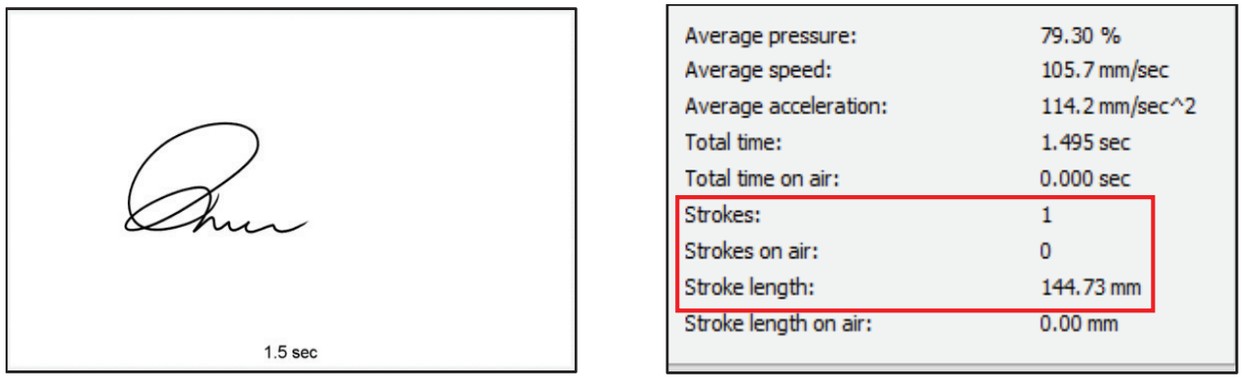


Figure 8- *Signature n. 10 - abbreviated signature without air-stroke with short line - Latin style*

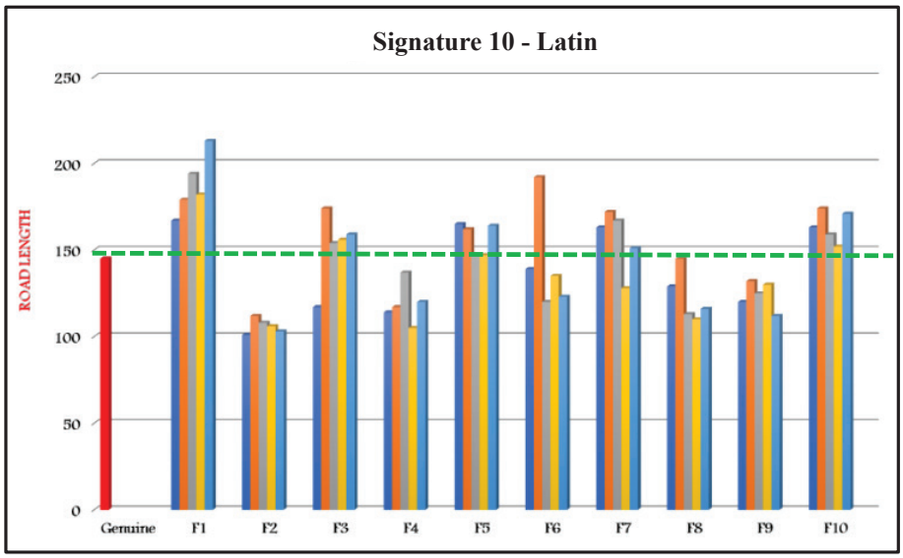


Figure 9- *Result of the all forged signature n. 10 compared to the genuine one were the line length is short - Latin style*

4. Conclusion

The acquired data allowed for the first comparison of “line lengths” between genuine and forged signatures, allowing for a deeper understanding of this "new" component of the handwriting test.

The results of this study, focused only on the length of the line and not on other characteristics, has provided confirmations of axioms already known (also reopening new questions) but also “new" data regarding a characteristic never "explored" and studied:

Confirmed axioms and principles:

- The synchronic and simultaneously realized signatures show similar characteristics due to neurophysiological automatisms that, just because they are synchronic, become more difficult to control - (Are we sure that collecting known signatures in a single circumstance is a technically correct choice?).
- The forgers have constantly focused their attention on the pictorial characteristics of genuine signatures without worrying about the length of the line and other characteristics such as speed and air-strokes in-air trajectory (IAT) (characteristics that will be the subject of different and further studies).
- There are forgers who, despite being lay people, have better skills and predispositions than others to forge the signature pictorially.
- The study of the length of the line (also called "Road Length") is a highly personal feature that, without losing sight of its natural and genuine variability, deserves attention and deepening.
- Lay forgers have shown more difficulty in pictorially reproducing a signature of short line length.
- The measurement of the "Line Length" can be performed both on digitally captured signatures (DCS), as in this preliminary study, but also on traditional signatures and lines (P&P) -

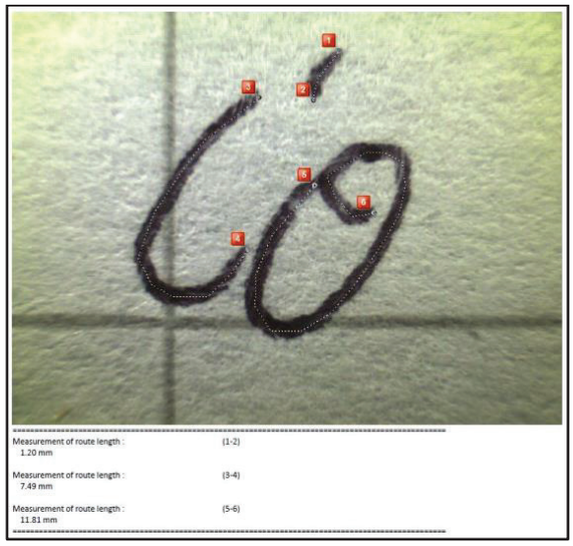


Figure 10- *Example of line measurement on stroke in P&P signature*

In the list of qualities that characterize "complexity" (i.e. number of changes in direction, numbers of intersection of the line and so on), we can include, thanks to the new hardware & software solutions available, also this “new” feature never analysed and compared before this study and research.

Conflict of interest

The authors declare no conflicts of interest.

Source of funding

The authors received no financial support for the research, authorship or publication of this paper.

References

1. Best Practice Manual for the Forensic Examination of Handwriting ENFSI-BPM-FHX-01 -Version 04 - November 2022 - pp. 74-112 - www.enfsi.eu/documents/best-practice-manuals -
2. Dumortier J. Regulation (EU) No 910/2014 on electronic identification and trust services for electronic transactions in the internal market (eIDAS Regulation). InEU Regulation of E-Commerce 2017 Apr 28 (pp. 256-289). Edward Elgar Publishing.

3. Found B, Rogers D. The forensic investigation of signature complexity. Handwriting and drawing research: Basic and applied issues. 1996:483-92
4. Huber RA, Headrick AM. Handwriting identification: facts and fundamentals. CRC press; 1999 Apr 15.
5. Mohammed LA. Forensic examination of signatures. Academic Press; 2019 Jun 6.
6. Best Practice Manual for the Forensic Examination of Handwriting ENFSI-BPM-FHX-01 -Version 04 - November 2022 - Appendix 6 - pp. 72-92 - www.enfsi.eu/documents/best-practice-manuals -
7. Geistová Čakovská B, Kalantzis N, Dziedzic T, Fernandes C, Zimmer J, Branco MJ, Heckeroth J, Spjuth KA, Kupferschmid E, Vaccarone P, Kerkoff A. Recommendations for capturing signatures digitally to optimize their suitability for forensic handwriting examination. Journal of Forensic Sciences. 2021 Mar;66(2):743-7.
8. Recommendations for Capturing Signatures Digitally to Optimize their Suitability for Forensic Handwriting Examination - B.G. Čakovská, N. Kalantzis, T. Dziedzic, C. Fernandes, J. Zimmer, M.J. Branco, J. Heckeroth, K.A. Spjuth, E. Kupferschmid, P. Vaccarone, A. Kerkoff - JFS Journal of Forensic Sciences - Wiley Online Library - 18 November 2020 - https://doi.org/10.1111/1556-4029.14627
9. Heckeroth J, Kupferschmid E, Dziedzic T, Kalantzis N, Čakovská BG, Fernandes C, Branco MJ, Spjuth KA, Kerkhoff A, Vaccarone P, Zimmer J. Features of digitally captured signatures vs. pen and paper signatures: Similar or completely different?. Forensic Science International. 2021 Jan 1;318:110587.
10. Best Practice Manual for the Forensic Examination of Handwriting ENFSI-BPM-FHX-01 -Version 04 - November 2022 - pp. 82-112 - www.enfsi.eu/documents/best-practice-manuals -
11. Zimmer J, Kalantzis N, Dziedzic T, Heckeroth J, Kupferschmid E, Fernandes C, Čakovská BG, Branco MJ, Spjuth KA, Vaccarone P, Kerkhoff A. The challenge of comparing digitally captured signatures registered with different software and hardware. Forensic Science International. 2021 Oct 1;327:110945.