Latest trends in signatures and signature fraud detection

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Abstract

With the development of the digital society, forensic analysis of signatures, in addition to the traditional analysis of signatures written with a writing medium on a common writing base, has also expanded to the analysis of signatures that are digitally scanned or digitally captured. Digitally scanned signatures represent some authentic signatures that have been scanned and implemented in the disputed document using computer technology and can in no way be considered authentic, especially if the scanning was performed by a person whose name is not signed in the disputed signature. Digitally captured signatures are gradually replacing the traditional way of signing, especially in banking transactions both within the Republic of Croatia and internationally. They become part of the modern forensic analysis of signatures and represent the authentic signatures of a person who made the writing with his own handwriting with a pen on the signature plate.

The paper aims to present the latest trends in the development of technologies used for signing and also to present the latest trends in signature forgery. Additionally, in this paper, we present the possibilities of analysing such signatures in potential real situations.

Keywords: signatures, digitally captured signatures, forensic signature examination, counterfeit

Highlights

- Signature examination as a part of the forensic analysis of handwriting
- With the development of the digital society, forensic analysis of signatures has expanded to the new analysis
- Digitally scanned signatures represent scanned authentic signatures
- Digitally captured signatures are handwritten signatures made by signing electronic documents on a tablet or a similar electronic device

1. Introduction

Handwriting is a form of communication. In order to make it understandable to everyone, when we first learn to write, we use a controlled way of writing. This means that we write with school-type handwriting, the so-called "copybook" model without any apparent individual handwriting characteristics. As we mature, our consciously controlled writing is replaced by spontaneous writing, resulting in the development of handwriting individuality and departure from school handwriting.

On the other hand, signatures (a person's name handwritten with a writing instrument) as one of the forms of individual identification, represent the most automated and the most common way of graphomotor expression of a particular individual.

The need to forge signatures occurred simultaneously with the introduction of public documents, and it dates back to ancient Greece and Rome. [1] Signature forgery is therefore related to many forms of criminal conduct - from identity theft, and financial and accounting crime, all the way to terrorism.

With the emergence of forgeries, a need to establish the authenticity of questioned handwriting or signatures arises. More precisely, when it is determined that a questioned handwriting or signature is not authentic, a need arises to identify the forger and the method of forgery. First

handwriting and document experts appear at the same time. Initially, they were self-taught.

Today's contemporary method used in handwriting expertise includes forensic analysis of handwriting, and it is defined as the expert determination of the handwriting origin by analysing and comparing class and individual handwriting characteristics contained in the questioned and unquestioned handwriting. [2]

Signature examination in itself represents a part of the forensic analysis of handwriting which is based on two main principles. The first principle is based on the fact that every handwriting and/or signature is unique, which means that they represent identification characteristics specific to that writer. The second principle is based on the fact that there are no two persons with handwriting and/or signatures which are completely identical in terms of all class and individual handwriting characteristics. [3]

With the development of the digital society, the ways of signing have gradually changed and thus, in addition to the traditional analysis of signatures written with a writing medium on a common writing base, forensic analysis has also expanded to the analysis of signatures that are digitally scanned or digitally captured.

Therefore, this paper aims to present the latest trends in the development of technologies used for signing and also to present the latest trends in signature forgery. Additionally, in this paper, we present the possibilities of analysing such signatures in potential real situations.

2. Signature examination

For thousands of years, signatures have been accepted as a form of personal identification. The principles that apply to handwritings also apply to signatures and they primarily postulate that every signature is unique and represents identification characteristics specific to the writer. Moreover, there are no two persons with signatures which are completely identical in terms of all class and individual handwriting characteristics.

In order to create their signatures, individuals adopt numerous writing strategies and with time develop a unique signature. In some cases, an individual may use more than one signature or way of signing. [4] This is something that experts must always take into account during forensic examination. Therefore, in order to conduct an efficient analysis, it is necessary to have as many samples of clearly unquestioned material as possible to be able to identify all individual handwriting characteristics of the scriptor.

However, we can sign with different writing media, from lead pencils, ballpoint pens, felt-tip pens, fountain pens, and similar, and in the first phase of analysing a questioned signature, a document and handwriting expert identifies the medium with which the signature was made. A stereo microscope (Leica Microsystems) and a video spectral comparator are used for such an analysis. After that, general and individual signature characteristics are identified. [5]

2.1. General handwriting characteristics of signatures

General handwriting characteristics of signatures are also examined with a stereo microscope and a video spectral comparator. This includes, among other things, observing the general appearance of a signature (legible, scribbled, etc.), type of signature (initials, partial initials, reduced handwritten signature, handwritten signature, etc.), graphic maturity (lowest, medium or advanced degree), rhythm and dynamics of writing, signature size, degree of slant, direction of lines, as well as the pressure of the writing medium on the writing base.

Figure 1 shows two different types of signatures. The initials signature under a) in Figure 1 shows the characteristics of rapid and spontaneous signatures of distinct general graphic appearance without a clear definition of individual characters. Handwritten signatures are signatures with full first and last name or some other variation (first letter of a name and full surname, etc.). Handwritten signature under b) in Figure 1 consists of a full name and surname in the medium degree of graphic maturity, suitable rhythm and dynamics of writing, almost vertical slant, inconsistent direction of lines, and relatively poor general graphic appearance.

a) 

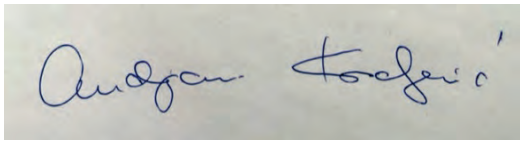


Figure 1. Examples of a) paraph signature and b) handwritten signature [7]

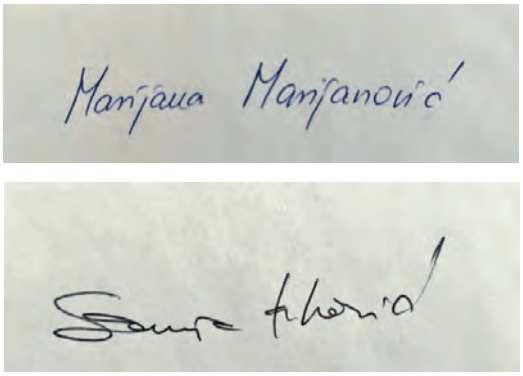


Figure 2 . Examples of signatures of a) clear and legible and b) poor and illegible appearance [7]

Figure 2 shows two signatures which differ in terms of general graphic appearance, graphic maturity, rhythm and dynamics of writing. Signature a) has the characteristics of a clear and legible general graphic appearance, right slant, controlled rhythm and pressure, medium degree of graphic maturity, and almost horizontal direction of lines. Signature b) has the characteristics of poor and illegible signatures, an advanced degree of graphic maturity, suitable rhythm and dynamics, and a slightly ascending direction.

1.2 Individual signature characteristics

Unlike general handwriting characteristics of a signature, individual handwriting characteristics cannot be clearly defined. Rather, they can primarily be found in small details of strokes, such as for example in the formation of prestrokes and initial strokes, signature size and geometry, the direction and number of strokes, diacritic placement, initial strokes when forming oval letters and similar.

3. Types of signature forgery

Signatures can be forged in various ways. One of the first methods of signature forgery included forgery by "copying" a signature. This involved tracing over an authentic signature so that it is copied on the desired document. When comparing such forged signatures with unquestioned, authentic signatures, major similarities were detected in the general appearance of the signature, slant and direction of lines. However, there were also big differences in the rhythm and dynamics of writing, as well as in the pressure, as can be seen in Figure 3. [1]

Figure 3. Comparison of a questioned signature a) made by copying and b) an authentic signature [1]

The second method of signature forgery is by "imitating" an authentic signature either by looking at an authentic signature or from memory of such a signature (Figure 4). Such questioned signatures are again characterised by great similarity in general appearance. However, the differences can be found in small signature details, the quality of strokes, and in particular in the rhythm and dynamics of writing. More specifically, these signatures will be more or less similar to the authentic signature which was used as an imitation template, depending on the forger's graphomotor skills.

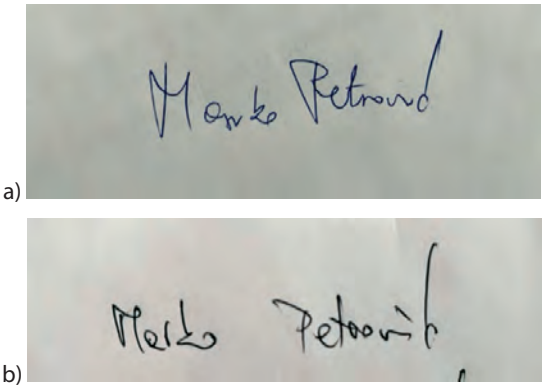


Figure 4. Comparison of a) a questioned signature made by imitation and b) an authentic signature [7]

In the case of the so-called "freehand forgery", a potential forger does not have an authentic signature as a template for his forgery but

is either using his memory or is fully creating a signature with his own handwriting (Figure 5). However, if one's own handwriting is used, a forger will very often, whether knowingly or unknowingly, change his own graphic expression in order to conceal his own identity.

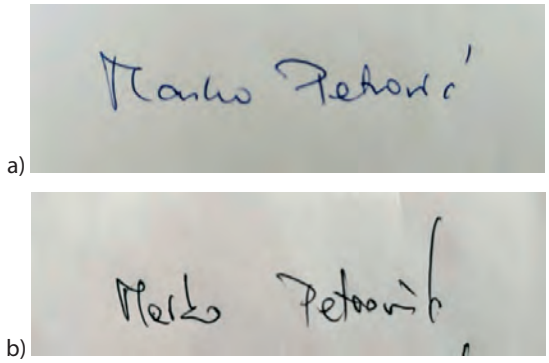
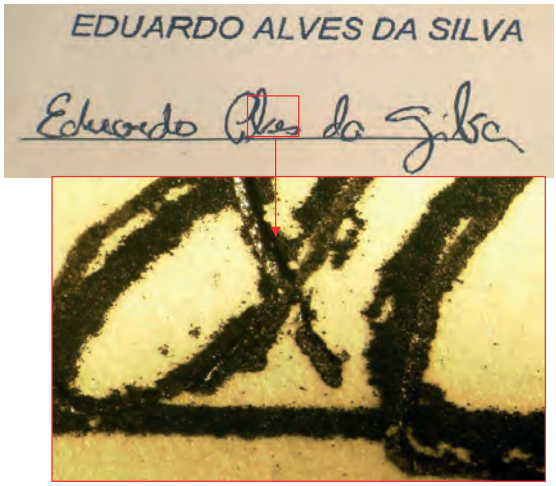


Figure 5. Comparison of a) a questioned signature made by freehand forgery and b) an authentic signature [7]

With the development of digital society, the methods of forgery have also changed and thus, the first types of such forgeries included signatures produced by photocopying an authentic signature which was then inserted (e.g. glued) into the relevant document, after which the entire document was photocopied once again (Figure 6). Later on, forgers very often trace over such a signature with a writing medium in order to conceal their forgery, which can easily be detected by analysing the document with a stereo microscope. Picture 6 shows a signature made in such a manner and an enlarged section of the signature clearly shows tracing over with a writing medium.



Picture 6. A signature made by photocopying after which parts of the signature were traced over with a black writing medium [1]

On the other hand, forgery by scanning involves scanning of an authentic signature which is then saved in file formats such as JPG, BMP, PNG, etc. Such a signature can then be inserted into any Word document and then printed from any of the available printers (e.g. Ink-Jet printers or dry ink printers). Figure 7 shows the comparison of a stroke made with a blue ballpoint pen and the same stroke which was scanned, inserted in a document and then printed from an Ink-Jet printer.

Figure 7. Comparison of a stroke a) made with a blue ballpoint pen and b) the one printed from an ink jet printer [1]

Forged signatures made by photocopying or scanning do not contain all the general and individual characteristics of signatures made with a writing medium. These primarily refer to the rhythm and dynamics of writing and writing pressure.

4. Biometric/digitally captured signatures

Biometric signatures of digitally captured signatures are signatures made by signing electronic documents on the basis of a handwritten signature made on a tablet, computer screen or a similar electronic device.

Once a handwritten signature is made, it is converted into a PDF document and stored as a biometric signature.

In addition to general and individual characteristics, such signatures also have some other characteristics. More precisely, in addition to the general appearance of a signature (a signature photo), there is also information about a biometric signature (the rhythm and dynamics of writing, length of writing, pressure, signature size), as well as a timestamp, location, IP information, ID image, etc. [6].

According to market research, the global market of digitally captured signatures is rapidly growing and by 2026, it will reach 22.1 billion dollars. The largest growth has been seen in the banking sector, insurance companies and telecommunications industry.

When we look at the components of devices used for such signatures, we can see that they consist of hardware and software. The device itself represents the hardware (a signature plate and a computer), whereas the software analyses the signature type and size, writing speed, pressure, and the total duration of writing. As a result of such an analysis, a software program creates a unique PDF document which represents a biometric signature.

Likewise, when subsequently verifying a digitally captured signature, the software compares the previously stored signature with the newly captured signature in the same manner, which means that it compares their type and size, writing speed, pressure and the total duration of writing.

Figure 8. A signature plate and stylus [8]

5. Examples from practice

5.1. First example

As an example from practice, Figure 9 shows a signature made with a blue ballpoint pen (under visible light, oblique light and oblique light in the IR field of radiation) and the same signature after it was scanned and printed from an Inkjet printer (Figure 10).

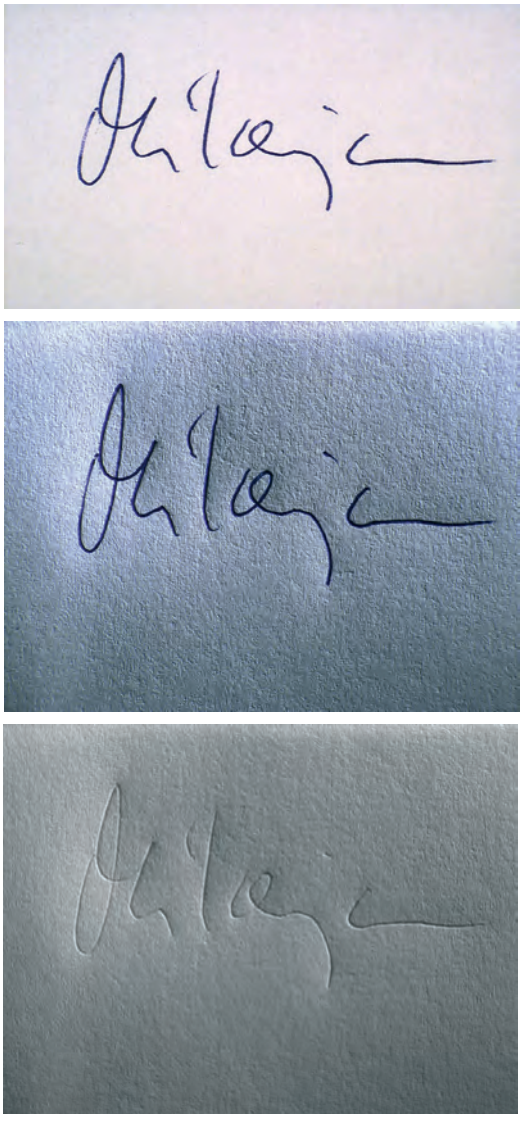


Figure 9. A signature made with a blue ballpoint pen a) under visible light, b) under oblique light, and c) under oblique light in the IR field of radiation [7]

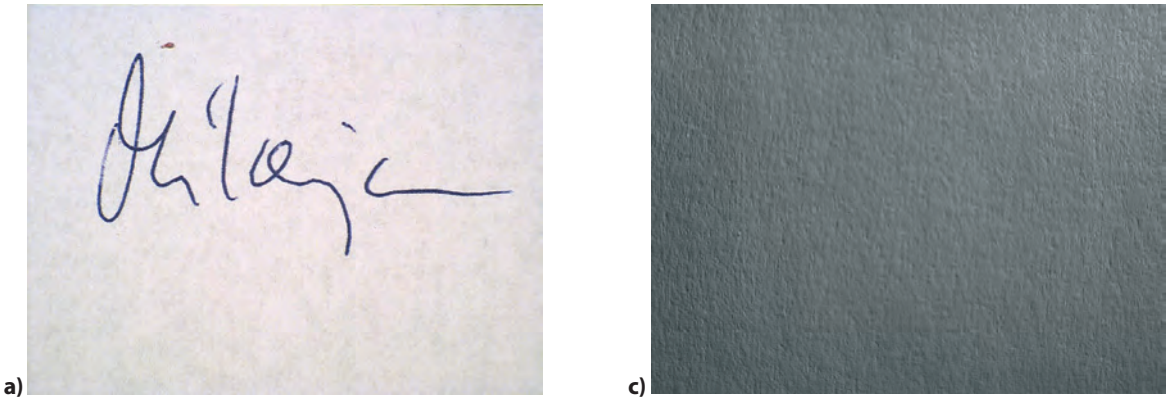


Figure 10. The same signature was scanned and printed on an Ink-jet printer a) the entire signature under visible light, b) an enlarged detail, and c) under oblique light in the IR field of radiation [7]

Figure 11 is a comparison of these two signatures that shows that the questioned signature was made by scanning the unquestioned signature and was inserted with the use of computer technology in another document, after which the entire document was printed on an Ink-jet printer. Such a signature is fully superimposed and identical to the unquestioned signature. This is an exact type of forgery.

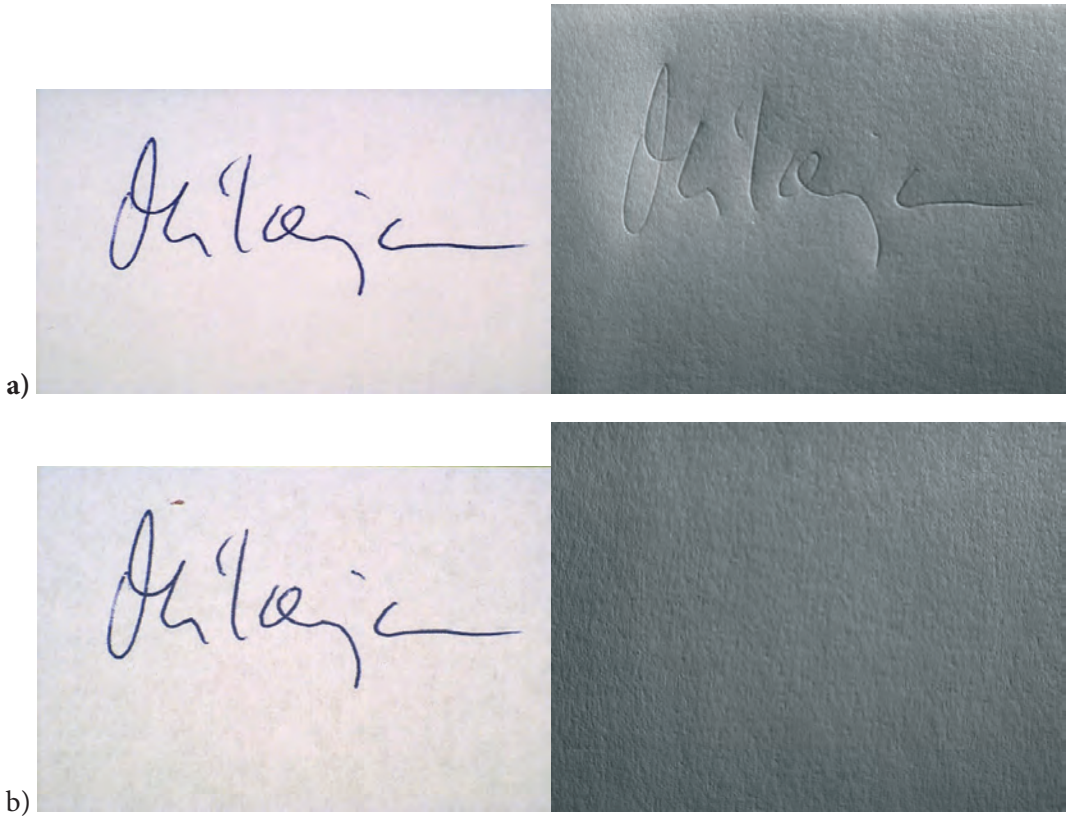


Figure 11. Comparison of a signature a) made with a blue ballpoint pen and b) a signature that has been scanned and printed on an Ink-jet printer [7]

4.2 Second example

Figure 12 shows three signatures from the same person written on a signature plate on different occasions.

Figure 12. Three signatures from the same person written on a signature plate on different occasions [7]

The available software program analysed the type and size, writing speed, pressure and the overall time it took to write out each signature separately. It produced unique PDF files representing three biometric signatures. The same program was then used for simultaneous comparison of all three biometric signatures based on writing speed, slant and pressure (see Figures 13-15).

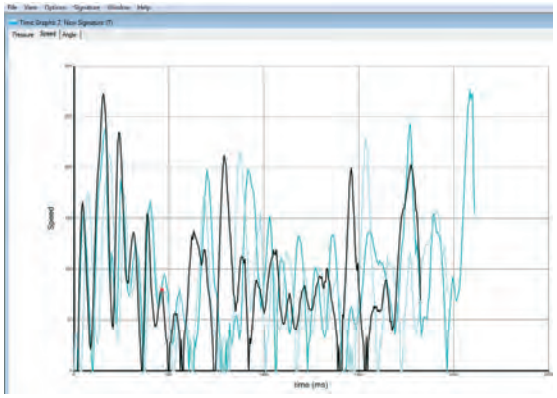


Figure 13. Writing speed comparison for all three signatures [7]

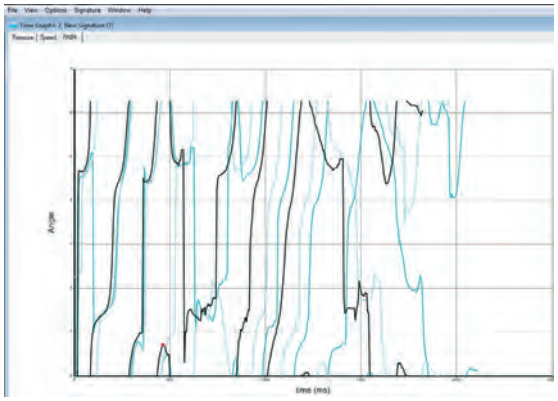


Figure 14. Slant comparison for all three signatures [7]

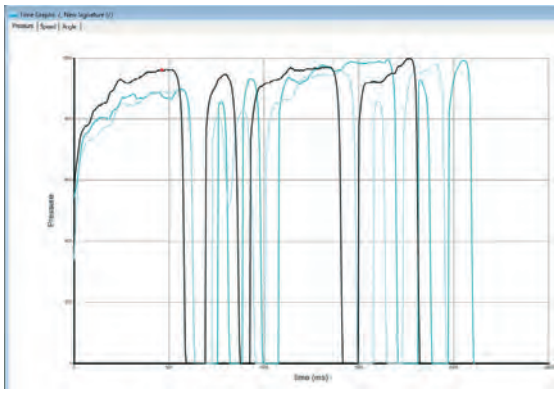


Figure 15. Pressure comparison for all three signatures [7]

These show great similarities in the above handwriting characteristics, on the basis of which it can be concluded that a single (same) person is the scriptor of all three signatures.

A traditional analysis was carried out for signatures and their printouts, including the comparison of general and individual handwriting characteristics. Similarities were found in all relevant handwriting characteristics thus leading to the conclusion that a single (same) person was most likely the scriptor of all of these signatures.

The opinion rendered was not decided in either case since the software program has not been validated, whereas in the case of traditional signature analysis, the signatures were printed out and as such cannot be examined in the same way that original documents can, as they are missing many of the notable handwriting characteristics, such as the rhythm and dynamics of writing, pressure, etc.

4.3 Third example

In the next phase of the analysis, general and individual handwriting characteristics were compared between a traditional signature of a single person written out with a blue ballpoint pen and one of the three digitally captured signatures on a printed-out PDF document. Figure 16 shows great similarities in the general graphic appearance of signatures. It can therefore also be concluded that the scriptor is a single (same) person.

Figure 16. Comparison between a) a traditional signature and b) a biometric/digitally captured signature [7]

The opinion rendered in this case was also not decided since we compared a traditional signature written out with a blue ballpoint pen containing all of the notable handwriting characteristics with a digitally captured signature that was printed out and is missing many of the notable handwriting characteristics such as the rhythm and dynamics of writing, pressure, etc., all of which are required to give a decided opinion on the scripture.

4.4 Fourth example

As the fourth example, Figure 17 shows a comparison between an unquestioned, authentic biometric/digitally captured signature and a questioned, forged biometric/digitally captured signature.

Figure 17. Comparison between an unquestioned digitally captured signature (above) and a questioned digitally captured signature (below) [7]

Figure 18 and 19 show that the questioned signature (black) was written more slowly and with more pressure than the unquestioned signature (orange).

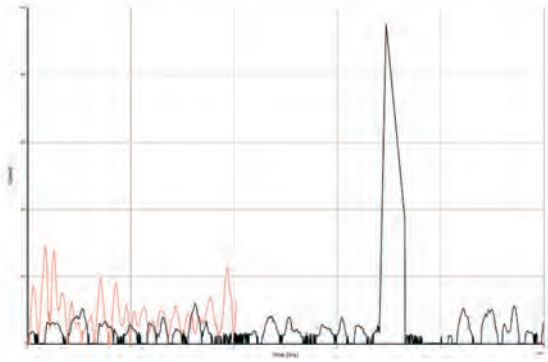


Figure 18. Comparison of writing speed between the unquestioned signature (orange) and the questioned signature (black) [7]

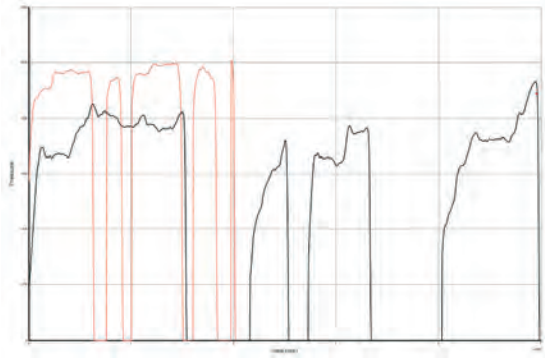


Figure 19. comparison of writing pressure between the unquestioned signature (orange) and the questioned signature (black) [7]

A traditional analysis of signatures was also carried out. General and individual handwriting characteristics were compared between the authentic digitally captured signature and the questioned digitally captured signature. Minor similarities were detected in the general graphic appearance of the signatures, as well as some notable differences that are indicated with blue arrows in Figure 17.

6. Conclusion

The modalities of signature forgery have changed significantly with the development of the digital society. In addition to the traditional method of forgery, which includes copy forgery, imitation forgery, freehand forgery, or photocopy forgery of an authentic signature, we are increasingly witnessing other methods of forgery, mostly digital scans of authentic signatures which are then inserted in questioned document using computer technology. Moreover, digitally captured signatures are slowly replacing traditional signing methods, especially when it comes to banking transactions, both in the Republic of Croatia and internationally, which leads to new methods of forgery.

The methods of forgery that are used with traditional signatures are also applied with digitally captured signatures.

It is clear from the above examples of authentic and forged signatures that handwriting and document experts can very easily identify forged signatures with the use of appropriate tools, both in cases of traditional methods of forgery and modern methods of forgery which include digitally scanned signatures as well as forgeries of digitally captured signatures.

The main conclusion that can be drawn is that, when examining a questioned signature, document and handwriting experts who have the necessary expertise, skills, and equipment to check the authenticity of a questioned signature will be able to verify whether the signature is authentic or forged. Accordingly, this paper covers the main developments in the methods used for signature forgery, as well as in the actual manner of signing, with the aim of demonstrating the issues in the detection of highly skilled contemporary signature forgeries. Finally, in order to ensure efficient and timely combating of criminal offences that are closely related to signature forgery, signature experts have to systematically follow the market for developments of newly emerging technologies, as well as the occurrences of new modalities of signature forgery.

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