Chapter 15
Dynamic Signatures as Forensic Evidence: A New Expert Tool Including Population Statistics

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Abstract This chapter presents a new tool specifically designed to carry out dynamic signature forensic analysis and give scientific support to forensic handwriting examiners (FHEs). Traditionally FHEs have performed forensic analysis of paper-based signatures for court cases, but with the rapid evolution of the technology, nowadays they are being asked to carry out analysis based on signatures acquired by digitizing tablets more and more often. In some cases, an option followed has been to obtain a paper impression of these signatures and carry out a traditional analysis, but there are many deficiencies in this approach regarding the low spatial resolution of some devices compared to original offline signatures and also the fact that the dynamic information, which has been proved to be very discriminative by the biometric community, is lost and not taken into account at all. The tool we present in this chapter allows the FHEs to carry out a forensic analysis taking into account both the traditional offline information normally used in paper-based signature analysis, and also the dynamic information of the signatures. Additionally, the tool incorporates two important functionalities, the first is the provision of statistical support to the analysis by including population statistics for genuine and forged signatures for some selected features, and the second is the incorporation of an automatic dynamic signature matcher, from which a likelihood ratio (LR) can be obtained from the matching comparison between the known and questioned signatures under analysis. An example case is also reported showing how the tool can be used to carry out a forensic analysis of dynamic signatures.

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15.1 Introduction

Forensic handwriting examiners (FHEs) have been carrying out studies about the authorship of handwritten signatures for court cases for over a century [1]. The great majority of works in the forensic field relates to offline signature analysis [2–7]. With the rapid evolution of technology, which allows the acquisition of dynamic signatures from tablets and smartphones, applications are spreading in the commercial sector to facilitate payments and also in banking to facilitate the digital storage of all the signed paperwork. Therefore, FHEs are being required to provide forensic evidence to determine the authenticity of handwritten signatures written on digitizing tablets [8], which can provide a static image of the signature but also, and most importantly, contain the dynamic information of at least the X and Y spatial coordinates over time.

Signature dynamics can be further processed to provide features such as the signing velocity, acceleration, and other stroke information along the signing trajectory. However, there are very few research works in the field of dynamic signature for forensic examinations [9–11]. The majority of relevant literature regarding dynamic signature analysis is in the field of biometric recognition [12], which make use of algorithms such as Hidden Markov Models [13, 14] or Dynamic Time Warping [15, 16].

In the last years there have been competitions on forensic signature verification for both offline and on-line signatures for automatic systems organized within the International Conference on Document Analysis and Recognition and (ICDAR) and the International Conference on Frontiers in Handwriting Recognition (ICFHR) from 2009 to date. It is interesting to note that in ICFHR 2010 offline signature competition, results of FHEs were also given allowing a comparison of performance of both automatic systems and FHEs [17]. It is also worth noting that in real practice FHEs carry out a multi-class problem classifying the signatures under analysis into genuine, forged, disguised (written by the authentic reference author, where he has deliberately tried to make the signatures look like a forgery, normally with the purpose of denying the signature at a later stage) or as inconclusive. On the other hand, automatic systems normally perform a two class problem deciding whether or not the given signature belongs to a referenced author. Results showed that different FHEs perform very differently, with some FHEs having very little opinion errors while some others many, and no correlation was observed with the experience in years of the FHEs or with the time (hours) they took to carry out the analysis (proficiency tests). Also, a significant percentage of FHEs decisions were inconclusive (between 30–50% of the datasets considered).

There are some commercially available tools for dynamic signature analysis (e.g., TOPAZ SigCompare[1] or KOFAX FraudOne[2]), which provide very limited functionalities to carry out a forensic analysis. This paper introduces e-BioSign, a new tool specifically designed to carry out forensic analysis of dynamic handwritten sig-

[1] http://www.topazsystems.com/sigcompare.html, accessed April 2015.

[2] http://www.kofax.com/products/kofax-signature-solutions/kofax-fraudone, accessed April 2015.

natures in order to facilitate the work of FHEs and give scientific support to their conclusions. In this sense, a survey of the methodology employed by the FHEs has been conducted and included in the functionalities of the tool. Together with these functionalities, e-BioSign tool also allows the measurement of dynamic information contained in the signatures, not taken into account normally by FHEs. With the use of dynamic signatures there is additional information available which can be used to carry out a more comprehensive and reliable forensic analysis.

Additionally, e-BioSign tool includes two important functionalities. On the one hand, it gives statistical support to the FHEs for some selected parameters such as the duration, fluency or level of tremor of the signatures. Population distributions for these parameters were computed for genuine and forged signatures allowing to position the questioned and known signatures under analysis on these distributions and extract some conclusions with statistical support. On the other hand, a dynamic signature verification system is included, from which a Likelihood Ratio (LR) can be obtained from the matching comparison between the signatures under analysis which is complementary to the analysis carried out by the FHE.

The remainder of the paper is organized as follows. Section 15.2 describes the traditional forensic practice followed to carry out the analysis of dynamic signatures. Section 15.3 describes e-BioSign tool with all its functionalities including the description of the statistical analysis carried out on a set of selected features in order to give statistical support to this forensic tool. Section 15.4 reports a Case Study using the tool for some genuine and forged dynamic signatures, and finally, Sect. 15.5 draws the final conclusions. This chapter is based on an extension of the previous work [18].

15.2 Forensic Practice for Signature Analysis

As mentioned, traditionally the practice of FHEs has been mainly concerned with the analysis of paper-based (offline) signatures. In order to carry out an analysis regarding the authorship of a questioned signature FHEs normally use some kind of variant of the following protocol.[3]

The first requirement is to have an appropriate set of signatures to perform the analysis, otherwise it wouldn't be possible to obtain convincing conclusions. Therefore, FHEs can ask the person whose signature is being investigated to provide a set of signatures (around 20) in order to have some samples produced with natural fluency. If the questioned signature was produced a considerable time before, then FHEs try to find some examples of contemporary genuine signatures.

Then, the analysis is performed taking into account aspects such as the **composition** of the signature (with or without name, surname, if legible, presence of flourish, etc.), **location** regarding other text or box (if it is close to the text or box on

[3]Based on published documentation from the Spanish Guardia Civil [4], the Netherland Forensic Institute [7] and the Victoria Police Forensic Services Centre (Australia) [3].

the right, left, etc.), **direction** (inclination of the written part regarding the horizontal, also the flourish), **written part** (FHEs carry out a comparison letter by letter), **flourish** (initial and final points and their direction), **fluency** and **pressure**. Even if in offline signature analysis fluency and pressure can not be measured as accurate as with dynamic signatures, this dynamic information is considered as an important and discriminative factor and it is estimated by analyzing the width of the stroke or the groove left in the paper.

Some important aspects taken into account by FHEs to detect forged signatures are the following: in general the forger is only able to focus in one of the two main aspects required to obtain a good quality forgery: (i) precision in the production of the signature (size, proportion and shape), or (ii) written fluently. Therefore, in general the forgeries can be precise regarding the appearance but not fluent, or written fluently but imprecise. Other signs to detect forgeries are changes in velocity in different strokes, tremors, monotonous pressure, traces of practice or guiding lines, unnatural pen lifts, corrections, etc. Also, the complexity of the signature is an important aspect to take into account as complex signatures are much harder to be forged.

15.3 e-BioSign Tool

This section describes the main functionalities of e-BioSign tool, which is a tool designed to be used by FHEs to carry out the analysis of dynamic signatures and give scientific support to their forensic reports. This first version of the tool has been developed under Matlab GUI interface, but a second version of the tool as an independent application is under development. The most important functionalities of this tool are:

- Several signatures can be loaded and visualized simultaneously (i.e., reference signatures and the signature under analysis).
- Signatures can be normalized in the spatial and time domains.
- Strokes can be manually selected for further analysis (to measure dimensions, angles, etc.).
- Statistical analysis of a selection of parameters can be conducted positioning the signatures under analysis in a population distribution.
- Automatic signature verification provides a matching score to complement the analysis of the FHE.

Next, the functionalities of e-BioSign Tool are described. We have divided these functionalities in four main modules.

15.3.1 Module 1: Signatures Loading and Normalization

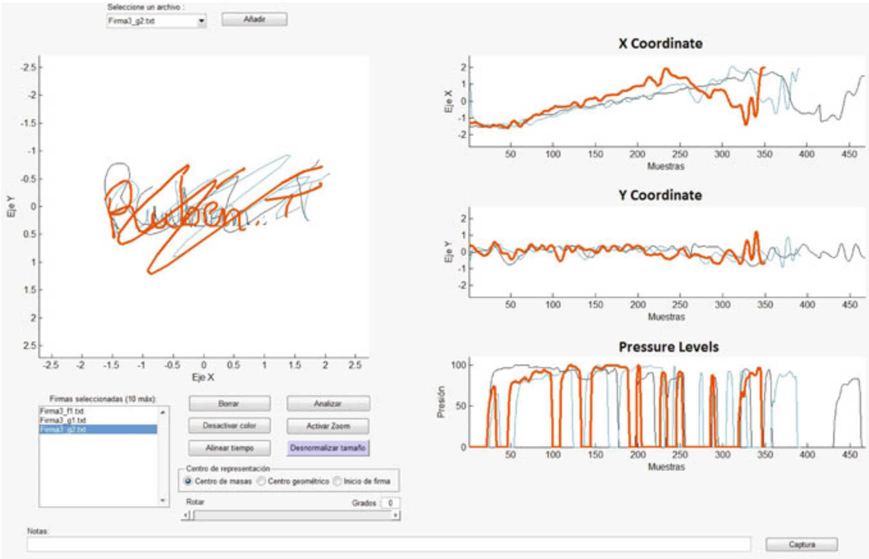
Module 1 allows to load several signatures for further analysis. The signatures can be visualized simultaneously, i.e., both the spatial image of the signature and the dynamic information of the X and Y coordinates and pressure. This is very useful as questioned and known signatures can be visualized at the same time allowing to analyze similarities and dissimilarities. Figure 15.1 shows a screenshot of Module 1 of e-BioSign tool with three signatures loaded, two of them genuine and one forgery.

When loading the signatures the information regarding frequency sampling (in Hz) and spatial resolution (pixel per inch) needs to be entered in a pop up window. In the example shown in Fig. 15.1a it is interesting to see how the two genuine signatures (orange and blue) have similar time duration, while the forgery (black) has a longer duration. In Module 1, it is also possible to normalize the loaded signatures both in the spatial domain and in the time domain. In the spatial domain, three position normalizations are possible considering different reference points: (i) center of mass, (ii) geometric center, or (iii) beginning of the signatures. A size normalization can be also applied maintaining the aspect ratio of input signatures. In the time domain, the signatures can be resampled to have the same time length. Figure 15.1b shows the same three example signatures shown in Fig. 15.1a after time normalization. In this case, it is possible to see how the two genuine signatures provide a good match in X, Y and pressure values, while there are more dissimilarities (especially in the pressure) regarding the forged signature.

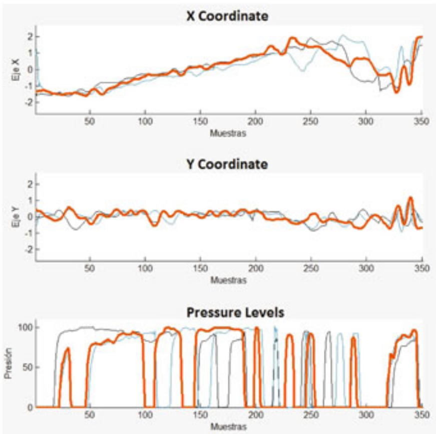
15.3.2 Module 2: Individual Signature Analysis and Stroke Selection

Module 2 allows to analyze the input signatures independently, and also to select strokes from each signature for further analysis. In order to analyze each signature, it is possible to reproduce the realization of the dynamic information of the signature, both in the spatial and time domains, with or without considering the pen-up dynamics. The pen-up dynamic information can be also visualized in the spatial representation. This is very interesting as this information can be very discriminative. Also, the pressure level information of each point can be incorporated in the visualization through a color map. Figure 15.2 shows a screenshot of Module 2 with one signature, in which the signature is represented with a color map based on the pressure values, and also the pen-up information is visible (in pink).

This module also allows to select strokes from the signature for a more detailed analysis. The strokes can be selected both by choosing initial and final points in the spatial representation of the signature, or using sliding bars in the time representation.



(a)



(b)

Fig. 15.1 **a** Screenshot of e-BioSign tool Module 1, which allows to load several signatures and carry out a joint analysis. **b** Same signals normalized in time

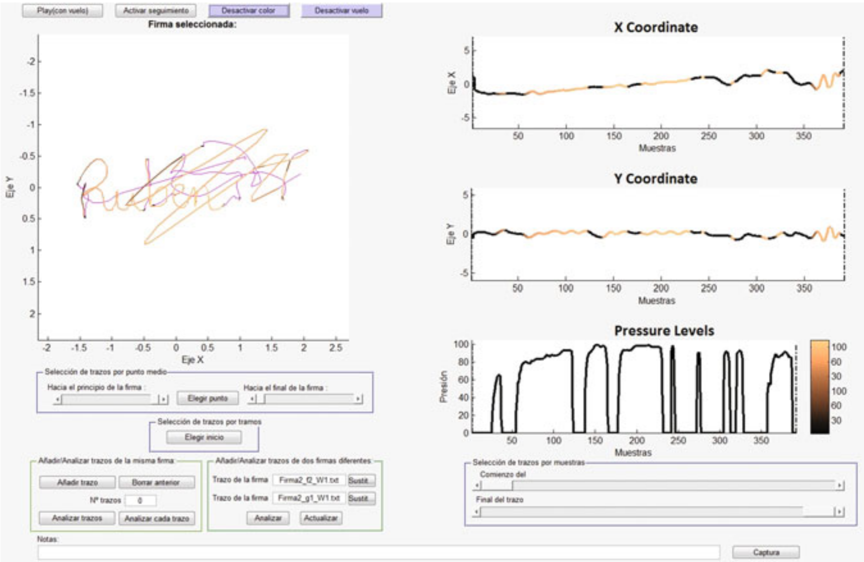


Fig. 15.2 Screenshot of e-BioSign tool Module 2, which allows to analyse signatures individually reproducing the dynamic of the signature and showing the pen-up information. Strokes can be selected for further analysis

15.3.3 Module 3: Strokes Analysis

Module 3 allows to carry out a more detailed analysis of the selected strokes from the signatures. It is worth noting that the whole signature can be also selected as one stroke. Figure 15.3 shows a screenshot of Module 3. On the left part, it is possible to visualize the dynamics of the velocity and acceleration, and below again the X and Y coordinates and pressure. The analysis here can be conducted on single or multiple strokes at the same time, from one or more different signatures.

In the middle part of Fig. 15.3 there are some additional functionalities: it is possible to rotate the stroke regarding the center of representation chosen (geometric center, center of mass or any other fixed points), the stroke thickness can also be selected, it is possible to zoom in and out the stroke and also the real sample points of the signature can be visualized. Moreover, this module allows to take measurements of the length (both in pixels and cm) and the angle of any segment with respect to the horizontal line (in degrees).

Module 3 also allows to carry out a statistical analysis of some features automatically extracted from the signatures, as can be seen on the right part of Fig. 15.3. The idea is to provide the forensic expert with a population distribution of genuine and forged signatures for a selection of features together with the actual value of these features for the signatures at hand. For the initial release of e-BioSign Tool five global features have been selected. Three of them are common in feature based

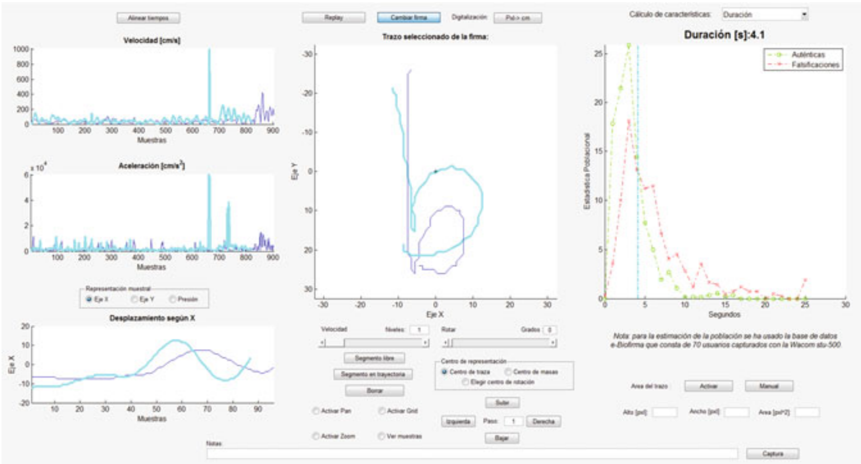


Fig. 15.3 Screenshot of e-BioSign tool Module 3. This module allows to carry out a detailed analysis of the selected strokes, it also allows to position the selected strokes (or signatures) in a population distribution of genuine and forged signatures for five selected features

dynamic signature recognition systems [14, 19]: total duration of the signature, average velocity and average acceleration. The other two parameters are commonly used in offline signature forensic analysis [2–6]: time fluency and spatial tremor. These two parameters are normally considered as good indicators to discriminate between genuine and forged signatures.

The **time fluency** of the signature is related to the number of samples with very low velocity in X and Y coordinates. Therefore, the time fluency was calculated following Eq. 15.1.

$$Fluency = \frac{-(N_{Vx} + N_{Vy})}{N} \tag{15.1}$$

where N_{Vx}, N_{Vy} and N correspond respectively to the number of samples with velocity in X or Y (Vx or Vy) equal or less than a threshold, which was set empirically to value 1 for obtaining Fig. 15.4, and N is the total number of time samples. The fluency is finally normalized in the range [0, 10] using an hyperbolic tangent normalization [20]:

$$Fluency' = \frac{10}{2}\{\tanh(1.5(\frac{Fluency - \mu}{\sigma})) + 1\} \tag{15.2}$$

where μ and σ are the mean and standard deviation of a set of signatures used exclusively to carry out the data normalization.

The **spatial tremor** present in the signatures can be due to low confidence in the realization of the (possibly forged) signature. The level of tremor of a signature was obtained using the Euclidean distance between the X and Y time functions of

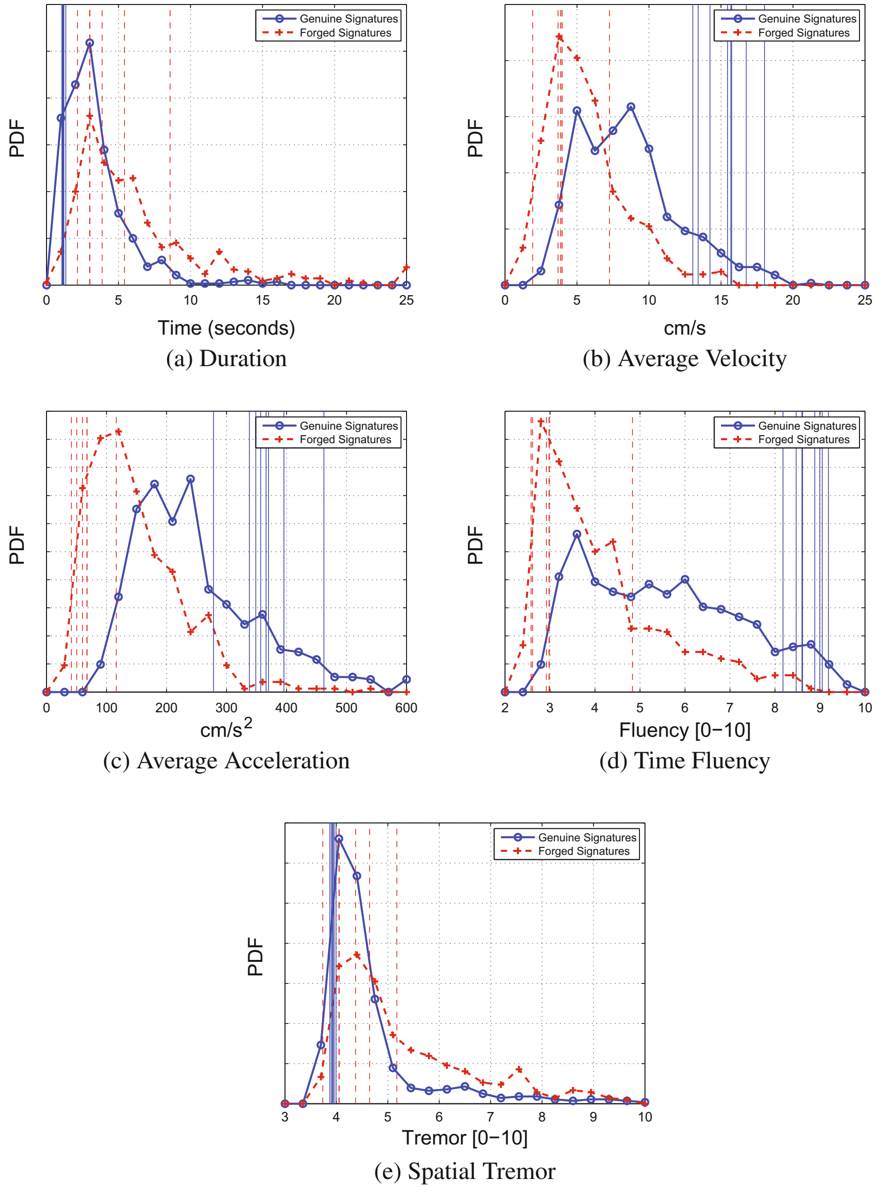


Fig. 15.4 Frequency histograms for genuine and forged signatures for the five selected parameters: **a** signature duration, **b** average velocity, **c** average acceleration, **d** time fluency, and **e** spatial tremor. *Vertical lines* show the positioning of the genuine and forgery signatures for a given user of the database

the signature to analyse and a smoothed version of them. This smoothed signature is obtained using a low pass Gaussian filter. Finally, these distance values for the tremor were also normalized to the [0, 10] range using the hyperbolic tangent method similar as before, adjusting the values of μ and σ accordingly for this case.

Figure 15.4 shows the population statistics for the five selected features. These distributions were obtained for a subset of e-BioSign database [21] which is comprised of 70 users signing on a Wacom STU-530 tablet. This database was comprised of eight genuine signatures per user and six skilled forgeries collected in two different sessions with a time gap of at least three weeks. The skilled forgeries signatures were performed in two different ways, in the first session forgers were allowed to visualize a recording of the dynamic realization of the signature to forge for a few times, while in the second session, a paper with the image of the signatures to forge was placed over the device and they can trace the lines to perform the forgery.

For each of the graphs shown in Fig. 15.4 we also show the position of the eight genuine and 6 forgery signatures with vertical lines for one of the users (as an example of use) inside the population distribution. This can help the FHEs to analyze if the questioned signatures are within the distribution of genuine signatures in general and for that user in particular. In the examples shown, it can be seen that for that particular user genuine and forgery signatures are well separated, especially for the average velocity, average acceleration and time fluency.

In a future release of e-BioSign Tool, in order to provide the FHEs with statistical support for these five parameters, apart from plotting population distributions, a Likelihood Ratio (LR) will be also provided for each parameter, which would be calculated from a matching score using the signatures under analysis, and using a LR model trained on a reference database (or a subset of it).

15.3.4 Module 4: Automatic Signature Verification

An additional functionality of e-BioSign Tool is Module 4, which is an automatic signature matcher. With this matcher, a questioned signature can be compared to a number of known or reference signatures to obtain a matching score.

The automatic signature matcher is based on a selection of time functions extracted from the signature such as the X and Y coordinates, the pressure, velocity, etc. Then, Dynamic Time Warping (DTW) is used to compare the similarity between the selected time functions extracted from the signatures [22]. The matching scores are then converted to likelihood ratios (LR) as commonly done in the forensic community [23–25]. In this case, e-BioSign database is used to train a likelihood ratio model following a logistic regression approach. As stated in [26], the aim of logistic regression is to obtain an affine transformation of an input dataset to generate an output value which optimizes an objective function. It may be demonstrated that logistic regression leads to LR values with low calibration loss from a training score set. In our case, Bosaris Toolkit [27] has been used.

In a first release of this tool, a person-generic LR model is considered, therefore obtaining same-source scores and different-source scores (in this last case comparing genuine signatures with skilled forgeries signatures). In future releases, functionalities to select a group of specific users by age, hand they use to sign, complexity of the signature, etc., will be provided in order to obtain more meaningful LR models for the particular case to study.

15.4 Case Study

In this section we describe a case study for e-BioSign Tool. In this example, we analyze two genuine signatures from a given user and two skilled forgeries. Signatures are acquired using a Wacom STU-530 device. The two skilled forgeries are performed in different ways, for the first one the forger places a printed copy with the signature to forge on top of the device and traces the lines to perform the forgery (for the remaining of the analysis we refer to it as *traced forgery*). For the second one, the forger carries out the forgery directly on the device after practicing a few times on a paper (we refer to it as *natural forgery*). In both cases, the forger is allowed to visualize a recording of the dynamic realization of the signature to forge for a few times in order to obtain good quality forgeries.

This case example is not meant to be an exhaustive forensic analysis of the signatures as the one that would be done by a FHE. The purpose is to show with real examples how the functionalities of e-BioSign Tool can be used to analyze and measure the similarities and dissimilarities of dynamic signatures.

First, signatures are loaded for their analysis on e-BioSign Tool. Figure 15.5 shows the two genuine signatures (Module 1). They are both normalized in the spatial domain by the center of mass. Both signatures have a similar time duration and a striking similar shape of their X, Y and pressure temporal values, even not being aligned in time. This shows that this user is very consistent performing his signature. There are some parts (beginning and end) with some time misalignments which can be better analyzed with functionalities present in Module 3 of the tool.

Figure 15.6 shows the same two genuine signatures and the traced forgery signature. As can be seen, the traced forgery has a much longer time duration with more than double number of samples (almost 2,000 samples which correspond to 10 s as the Wacom STU-530 was configured to sample at 200 Hz, compared to less than 700 samples for both genuine signatures), which can be a sign that the signature has been performed by a forger. Figure 15.7 shows the three signatures aligned in time, with the forgery having longer strokes in general (particularly at the flourish) and also shorter duration pen-ups.

Figure 15.8 shows the same two genuine signatures as previously and the natural forgery signature. As can be seen, this forgery contains a similar number of time samples compared to the two genuine and in general shows a similar shape. We will describe the subsequent analysis steps using these three signatures with the remaining modules of the tool.

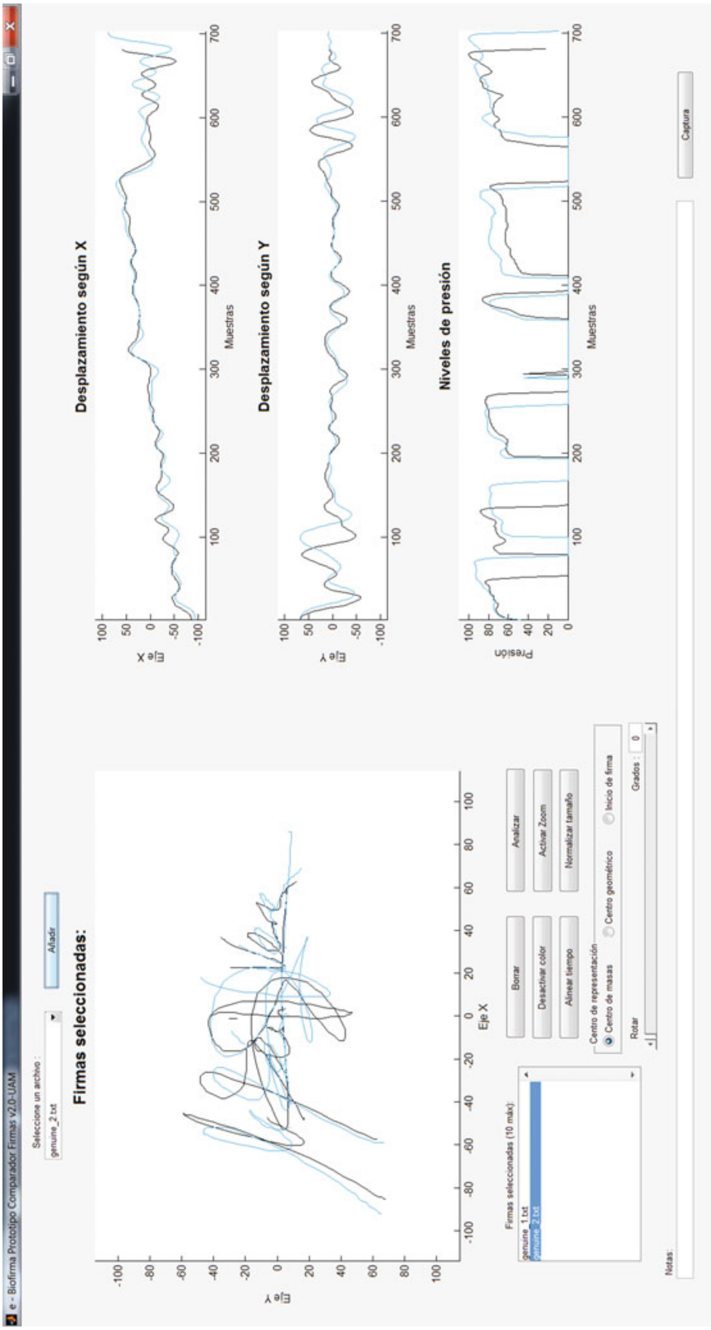


Fig. 15.5 Examples of two genuine signatures from the same user (reference known samples)

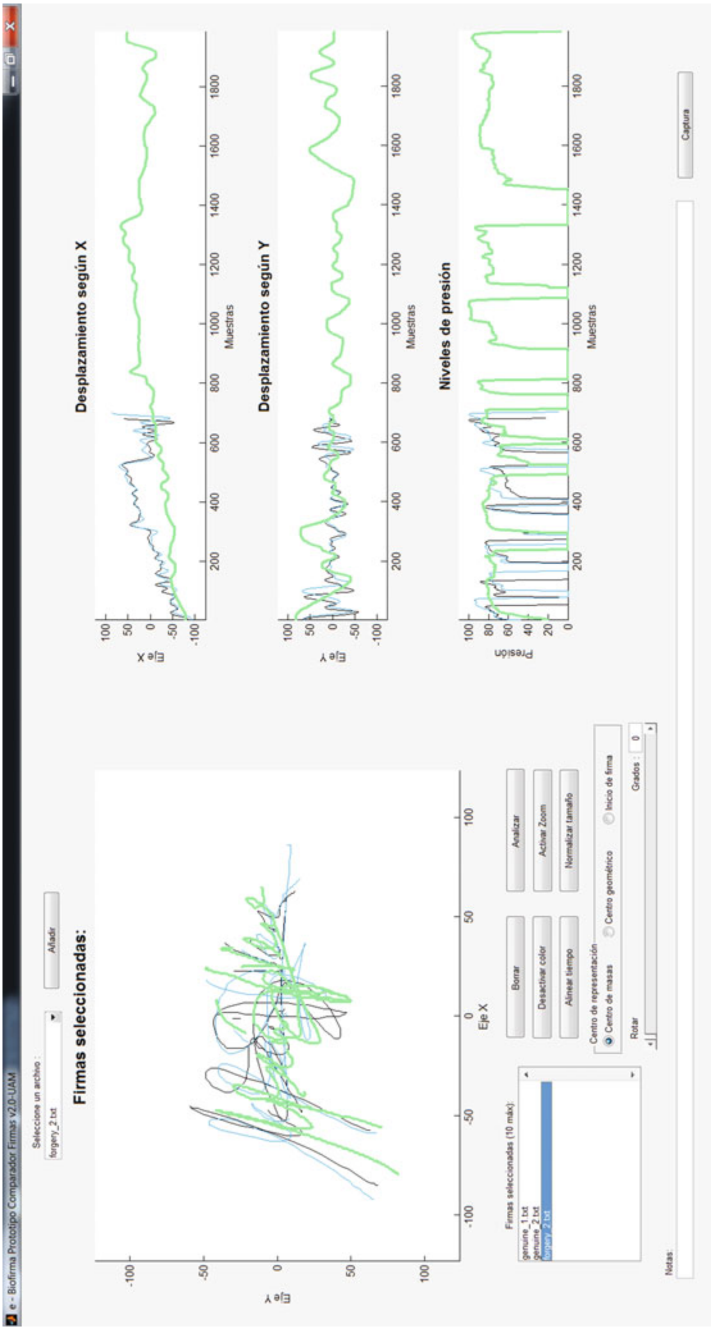


Fig. 15.6 Examples of two genuine signatures and one traced forgery signature

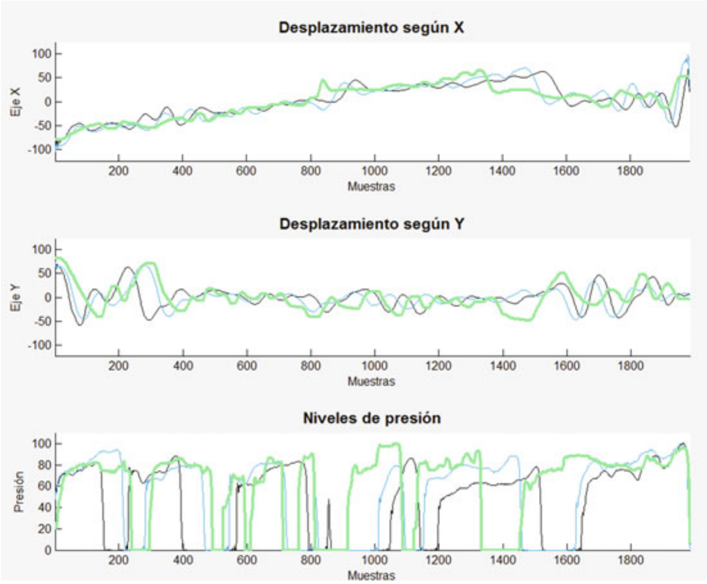


Fig. 15.7 Same signals as Fig. 15.6 but normalized in time

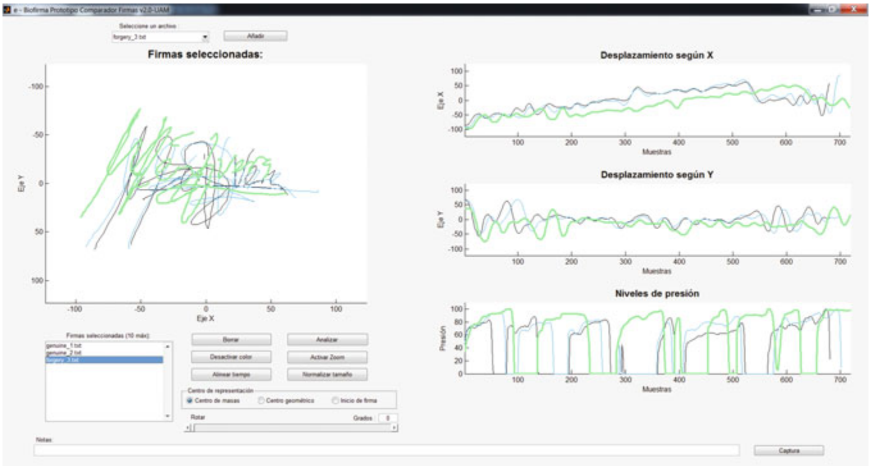


Fig. 15.8 Examples of two genuine signatures and one natural forgery

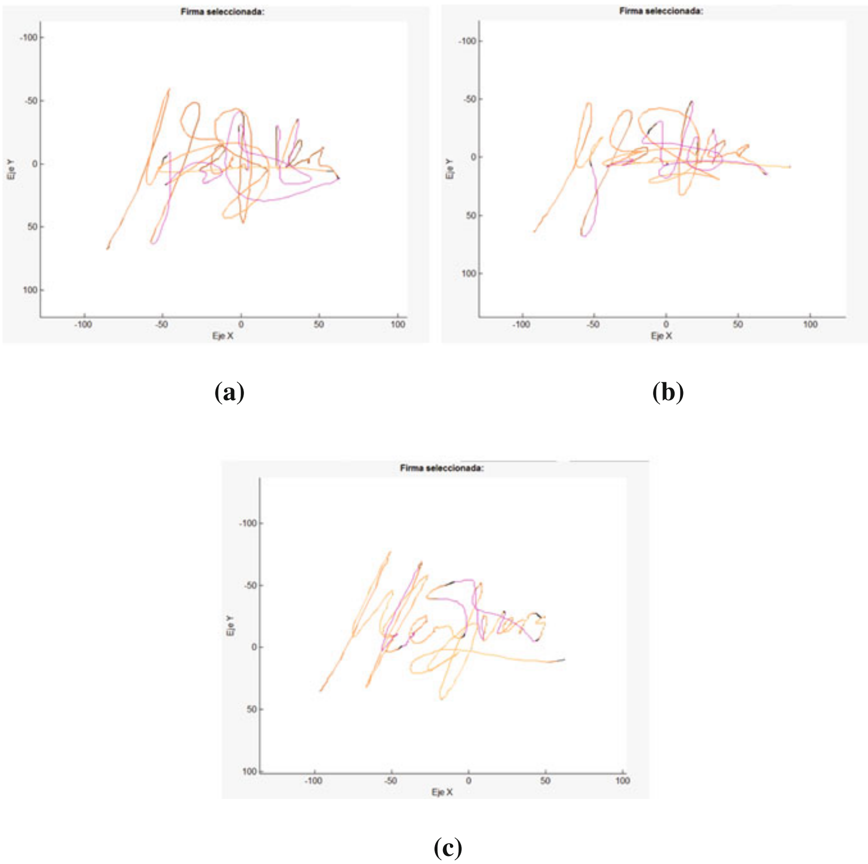


Fig. 15.9 Module 2. Spatial information (X and Y coordinates) also showing the pen-up information for **a** and **b** genuine signatures, and **c** forged signature

Module 2 of e-bioSign Tool is used to carry out a comparative general analysis of the signatures and to select some strokes for further analysis. Figure 15.9 shows the spatial information (X and Y coordinates) for the three signatures under analysis (the two genuine and the natural forgery). Also, the pen-up information is shown in pink color. Having a general look at the three signatures, there are some features quite different between the two genuine signatures and the forgery. For example, some letters have different shapes, or the last line of the flourish is placed just below the name letters for the genuine signatures, while it is placed much lower for the forgery. Additionally, Module 2 allows to visualize the direction of the trajectory of the signatures, indicating the beginning and end and connecting the different strokes as can be visualized in Fig. 15.10. With this functionality is easy to check that the signatures under analysis follow the same trajectory pattern.

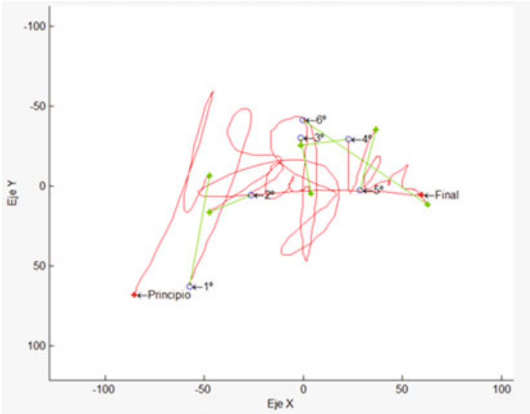


Fig. 15.10 Module 2. Trajectory information for one of the genuine signatures

Figure 15.11 shows the X and Y coordinates and pressure information along the time axis for the same three signatures. Having a close analysis to Fig. 15.11a, b, the two genuine signatures have very similar temporal information, following the same pattern for the X, Y and pressure axes. However, although there are some general similarities with the remaining signature (c), a close analysis reveals many differences, such as: the accent mark (samples around 300 for the two genuine and around 400 for the forgery) has a longer duration and higher pressure value compared to the two genuine; in general the pressure information presents higher values (for example see the last stroke). Also, the last part of the forged signature (Fig. 15.11c) (samples between 500 and 650) presents a completely different pressure pattern compared to the two genuine. Moreover, the are some strokes with very different pattern for the X and Y coordinates (the second stroke, for example). Some of these strokes of the signatures are selected for further analysis using Module 3 of the tool.

Module 3 of e-bioSign Tool is now used to carry out a more detailed analysis for some of the strokes selected with Module 2. Figure 15.12 shows the spatial and temporal information (X, Y, pressure, velocity and acceleration) that can be visualized in Module 3 for a comparison of the flourish stroke for the two genuine signatures (a) and one of the genuines and the forgery (b). These strokes have been aligned spatially for a better comparison with a shift in X and Y coordinates and rotation (for which the tool incorporates semi-automatic functionalities).

Figure 15.12a shows that even though the two flourish strokes do not have exactly the same spatial shape, the time functions follow a very similar pattern, with only a small difference in Y coordinates for samples between 60 and 90. It is possible to see how the velocity and acceleration functions follow a very similar pattern with just small time misalignments. On the other hand, Fig. 15.12b shows the same for one genuine signature and the forgery under analysis. In this case the differences between the two signatures are very significant both in spatial shape and for all the time functions.

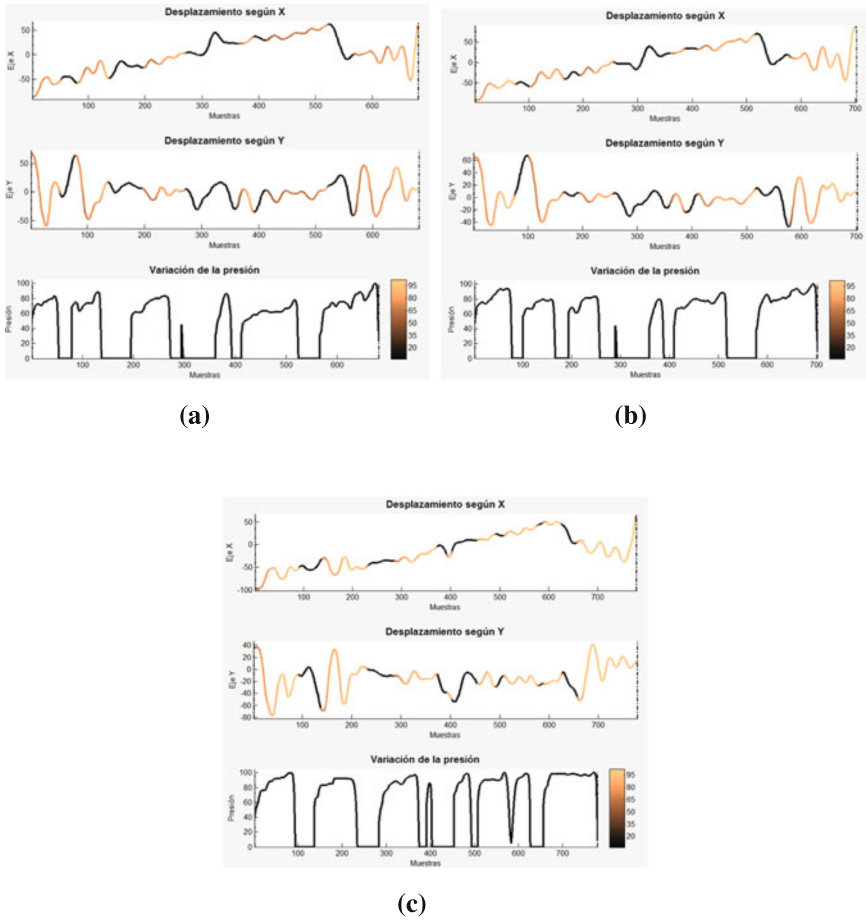
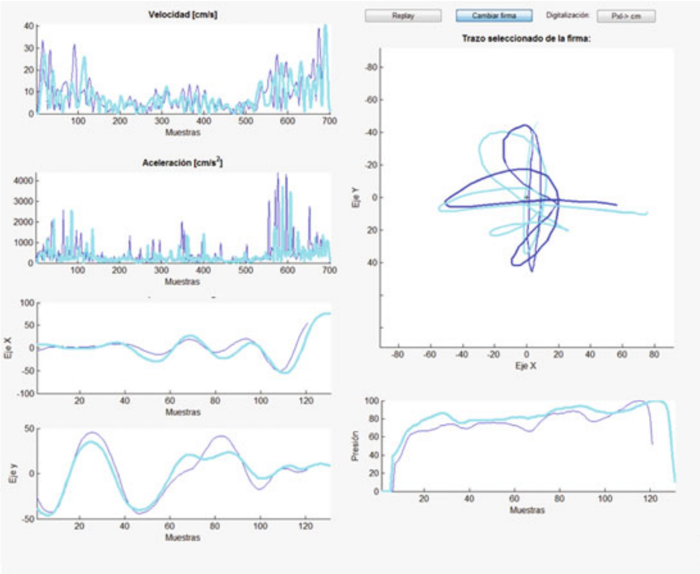


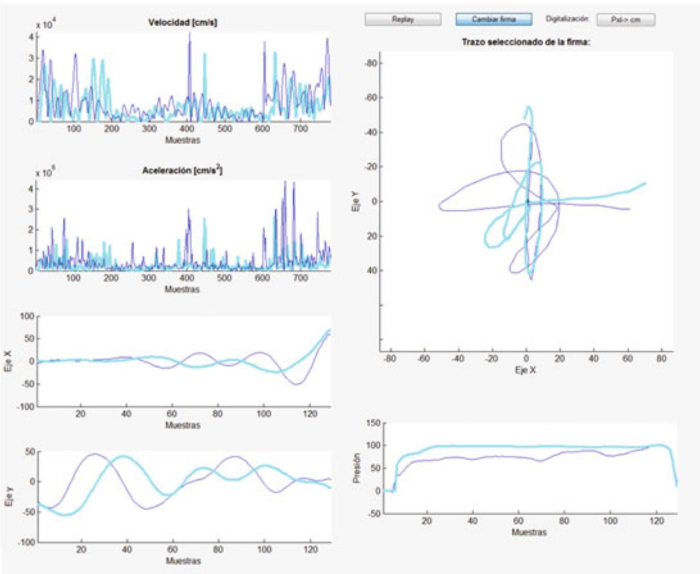
Fig. 15.11 Module 2. Temporal X, Y and pressure coordinates information for **a** and **b** genuine signatures, and **c** forged signature

For completeness, we also show in Fig. 15.13 the pen-up information that can be visualized (in red) with Module 3. In the case shown, following the trajectory of the pen-up information we can observe that the accent mark can be seen that is performed following a different trajectory for the genuine signature (a) and the forgery. This difference, although small, can be very significant for a FHE to give an opinion on these signatures.

Module 3 also allows to carry out a statistical analysis of five parameters extracted automatically. The values of these parameters for the four signatures considered in this case example are shown in Table 15.1. It is worth noting that in a real case analysis carried out by a FHE, a larger number of reference or known signatures should be considered (if possible) in order to carry out the analysis with higher statistical

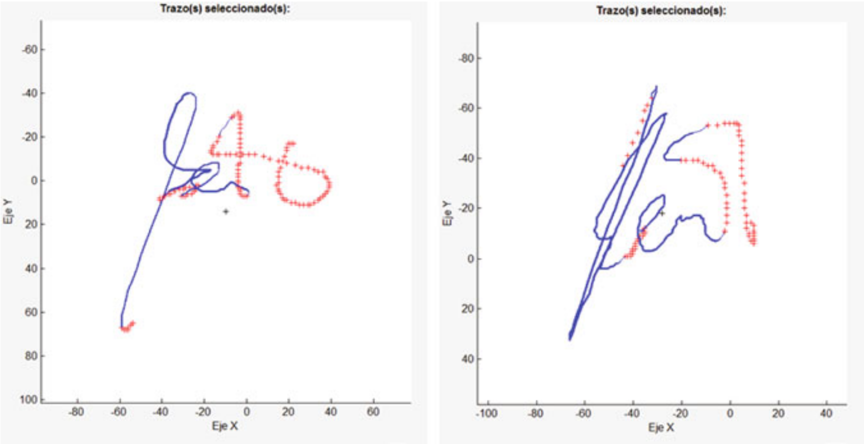


(a)



(b)

Fig. 15.12 Module 3. Comparison of the flourish stroke with their spatial and time information (X, Y, pressure, velocity and acceleration). **a** Genuine-genuine comparison and **b** genuine-forgery comparison



(a) **(b)**

Fig. 15.13 Module 3. Comparison of a stroke for one **a** genuine and **b** the natural forgery signatures with their spatial information. Also pen-up samples are shown for a more complete analysis

Table 15.1 Values of the five statistical parameters obtained for the four signatures under analysis. Time fluency and spatial tremor are normalized to the range [0–10]

	Genuine 1	Genuine 2	Traced forgery	Natural forgery
Duration (s)	3,4	3,5	9,9	3,9
Average velocity (cm/s)	8,4	7,7	2,6	6,4
Average acceleration (cm/s^2)	302,9	273,6	64,7	228,4
Time fluency	6,3	5,8	2,8	5,2
Spatial tremor	3,8	3,7	5,2	3,8

significance. The values shown in Table 15.1 can be visualized on top of the population distributions as per Fig. 15.4. As can be seen in the table, the two genuine signatures obtain similar values for the five parameters considered. Also, the natural forgery obtains similar values for these five parameters with just a bit longer duration, lower velocity, lower acceleration, lower fluency value and similar tremor value, but not very significant difference with just two reference signatures to compare. On the other hand, the traced forgery obtains very different values for the five parameters, which would indicate with a higher confidence this signature was produced by a different person.

15.5 Conclusions

This paper has described a new tool e-BioSign specifically designed to carry out dynamic signature forensic analysis and give scientific support to FHEs. This tool allows to analyse the traditional information taken into account by FHEs to carry out the analysis for paper-based signatures, and also permits to exploit the dynamic information contained in signatures acquired from digitizing tablets which can be very discriminative. As mentioned in Sect. 15.2 it is very difficult to perfectly forge a signature, good forgeries normally either have a similar appearance and shape but are not written fluently, or the opposite. With the analysis of both spatial and time information for dynamic signatures using e-BioSign, we believe it will be easier for FHEs to detect forged signatures. Additionally, the tool incorporates two important functionalities, the first is the provision of statistical support to the analysis by including population statistics for genuine and forged signatures for some selected features (signature duration, average velocity and speed, time fluency, and spatial tremor), and the second is the incorporation of an automatic signature matcher which can provide a matching score between the known and questioned signatures under analysis.

For future work, this tool will be provided to FHEs for testing and a new version will be released based on their suggestions. Also, LR values will be provided for the signatures under analysis for the five statistical parameters considered. FHEs will be able to select a particular subset of the reference dataset (based on the gender, hand used for writing, age, etc.) in order to obtain more meaningful LR values for the particular cases under analysis.

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