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Automatic usability and stress analysis in mobile biometrics ☆

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ABSTRACT

This article focuses on the usability evaluation of biometric recognition systems in mobile devices. In particular, a behavioural modality has been used: the dynamic handwritten signature. Testing usability in behavioural modalities involves a big challenge due to the number of degrees of freedom that users have in interacting with sensors, as well as the variety of capture devices to be used. In this context we propose a usability evaluation that allows users to interact freely with the system while minimizing errors at the same time. The participants signed in a smartphone with a stylus through the different phases in the use of a biometric system: training, enrolment and verification. In addition, a profound study on the automation of the evaluation processes has been done, so as to reduce the resources employed. The influence of the users' stress has also been studied, to obtain conclusions on its impact on both the usability systems in scenarios where the user may suffer a certain level of stress, such as in courts, banks or even shopping. In brief, the results shown in this paper prove not only that a dynamic handwritten signature is a trustable solution for a large number of applications in the real world, but also that the evaluation of the usability of biometric systems can be carried out at lower costs and shorter duration.

1. Introduction

One of the main drawbacks users find in biometric recognition [1] systems is the lack of usability. Almost all the work done in biometrics is devoted to improving algorithm performance and bringing the Equal Error Rate (EER) close to zero. But while this kind of research is necessary, working on improving user interaction with systems is also extremely important, as a lack of usability could mean not only the rejection of the system by the users, but also a reduction in the expected performance of the biometric system. There are previous usability works in biometrics in the literature [2] and most of them come from the usability definition given by the ISO 13407:1999 [3]: "*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use*". One of the most complete models published up to now is the Human Biometric System Interaction (HBSI) [4], which proposes methods and measures (including the ones recommended by ISO 13407:1999) to analyse the user–sensor interaction deeply. As this model has not yet been tested empirically in dynamic modalities [5], our work goes a step further, proposing some modifications to it, and therefore, the results obtained can be considered a novelty. Furthermore, this study includes stress tests where users sign under pressure conditions. The inclusion of these tests in the evaluation is motivated by some common scenarios where users are indirectly encouraged to sign quickly and carelessly (e.g. post offices, banks or supermarkets). Therefore, the main intention in this study is to measure the influence of stress in the recognition process, as this is one of the major concerns regarding usability and performance. These tests mean a novelty and an important advance in the improvement of security in mobile environments. Another relevant factor recently studied in handwritten signature recognition is the effect of ageing, which has been demonstrated to decrease the performance [6] [7]. In those works authors suggest different strategies to maximize the system accuracy over time, making the template updating less critical than expected.

It is important to note that the current tendency is to move from desktop computers to mobile devices, using them in mobile scenarios. Therefore the migration of biometrics to these scenarios has become an important topic nowadays. There are several published works focusing on the adaptation of biometrics to mobile devices, using different modalities such as the iris [8], hand [9] or fingerprint [10]. In our previous works with mobile devices and dynamic handwritten signature recognition [11], the algorithm applied was tested under different conditions but the evaluation of its usability was left for a future work, being covered by this paper.

In this experiment, 56 users (54 finished the whole process) signed in 2 sessions on a Samsung Galaxy Note [12] using a stylus. The process was split into user training, enrolment, verification and stress tests. Finally, the users had to complete a satisfaction questionnaire where they were asked about various usability aspects of the evaluation such

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as easiness or comfort. All signatures captured were real signatures (i.e. not invented, as they are the same ones that the users write when shopping with a credit card).

This paper is divided into 6 sections: in Section 2 the state-of-the-art is presented, while Section 3 explains the evaluation set-up, followed by a description of the experiments performed (Section 4). Results are shown and discussed in Section 5, finishing the paper with Section 6, where the conclusions obtained and the proposed future works are explained.

2. Previous works

The three best known first usability studies in biometrics were: an enrolment trial in the UK [13] conducted by Atos, the guidelines drawn up by NIST [14] and the HBSI model [4]. All of these measure the efficiency, effectiveness and satisfaction as defined by ISO 13407:1999, but HBSI goes further, focussing on the human–system interaction and the potential errors this relationship involves. Therefore, this is the baseline model applied to this work. The following subsections provide an explanation of the HBSI model and its application to handwritten signature recognition.

2.1. The HBSI

This model includes several measurements in order to complete a full usability analysis covering ergonomics and signal processing, as shown in Fig. 1. The HBSI was applied to various usability evaluations including most of the best known biometric modalities such as fingerprints [15] or hand geometry [16]. Nevertheless, the approaches to dynamic modalities were only theoretical [3], so this work proves the practical viability of the HBSI in behavioural biometrics. Additionally, this model incorporates interaction metrics in order to categorize the FTA (Failure to Acquire) errors during the sample acquisition process [3].

2.2. Handwritten signature in mobile devices

There are previous relevant studies in the literature about handwritten signature recognition in mobile devices [17] [18] and there are also commercial products using these kinds of algorithms [19]. Works previously carried out by authors regarding usability show interesting outcomes that have been applied to this experiment. These conclusions [8] are:

Mobile device Regarding performance and users' opinions, capacitive devices are the preferred ones. Moreover, users prefer signing with a stylus to using the fingertip. The screen size and the device operative system were not considered as influential parameters.

Usability None of the tested user positions for signing (seated or standing up; with the device resting on a table or held by the user) involves better performance results than the others and neither does the device situation. The users' training process has been demonstrated to be a highly influential factor for both effectiveness and efficiency [20], so we have considered this process indispensable. The expected time for users to complete the evaluation was reduced in this experiment (fewer signatures and sessions) with respect to previous usability evaluations [21] as many users complained about it.

3. Evaluation parameters

This evaluation set-up is in accordance with the conclusions obtained in previous works and the necessity to accomplish users' requirements in order to develop usable systems.

The experiment was divided into 2 sessions one week apart [22]. Training, enrolment and Verification 1 (V1) were done during session 1 (with pauses between them). Verification 2 (V2) and Stress-Influence Tests (SIT) were done in session 2 (also including pauses between them). Users could pause at any time to rest, except during the stress-influence testing.

3.1. Evaluation crew

The evaluation crew was composed of 56 users (37 men and 19 women) chosen without any special requirement. The only condition

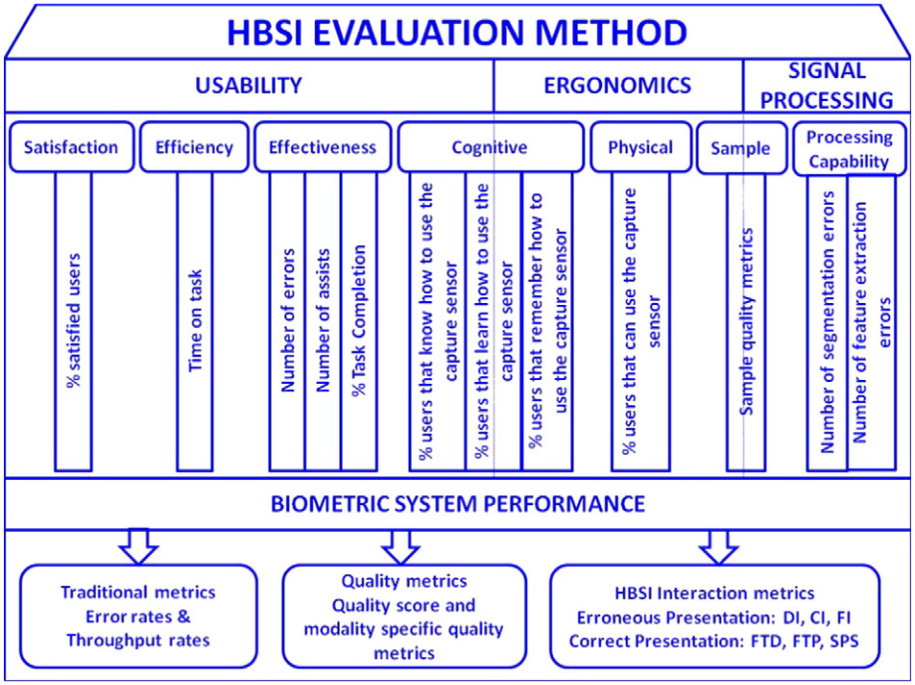

Fig. 1. HBSI Evaluation Method [3].