ALGORITHM OF A HANDWRITTEN SIGNATURE RECOGNITION ONLINE

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ABSTRACT

This document presents a technique for an online handwritten signature recognition system. A handwritten signature is an image obtained from an acquisition tool. It features dynamic and static: the dynamics are obtained from the acquisition and the static after image processing. The architecture of an online handwritten recognition system is divided into two modules, including the learning module and the module for comparison. The learning module is the creation of a model from the extracted features whereas comparison module consists in comparing the signatures to be verified or authenticated with the database models. An assessment was made by getting a false acceptance rate of 0.1% and rate of rejected true of 0.2%.

Keyword : - *recognition, handwritten signature.*

1. INTRODUCTION

Currently, biometrics is one of the most advanced recognition approaches. Evoking biometrics brings to mind the biometric modalities that are specific from one individual to another. Each category is defined by a subject with several features that makes it unique. The handwritten signature represents one of the biometric modalities: each individual has his own signature [1].

A handwritten signature is a graphic sign affixed by a person on a document. It has been of great value in society since its existence, particularly through its role of approving legal documents. Initially, it is on a physical support but given the digitalization race information in companies and Government it can now be placed on a digital medium. Otherwise, by the evolution of technology, it became another tool for the authentication to a system, same rank as the password but more reliable.

Thus, was born the handwritten signature recognition system. This allows to check or authenticate a digital handwritten signature. Two approaches can be considered such as the online or "on-line" approach and the off-line or "off-line" approach which differ by the acquisition of the signature.

In this paper we present a system of recognition of an online signature using dynamic and static characteristics of the signature considered as the most specific from one individual to another. The presented system includes two separates modules including the learning module and the comparison module. The learning module concerns the creation of a signature model while the comparison module compares the signature to be recognized with the model.

2. OVERALL PRESENTATION

A handwritten signature recognition system, like any biometric recognition system, follows a clear architecture. The architecture has two modules namely the learning module and the comparison module. In each module there are steps, each has a main action producing a result that will be the subject of another step (Fig-1).

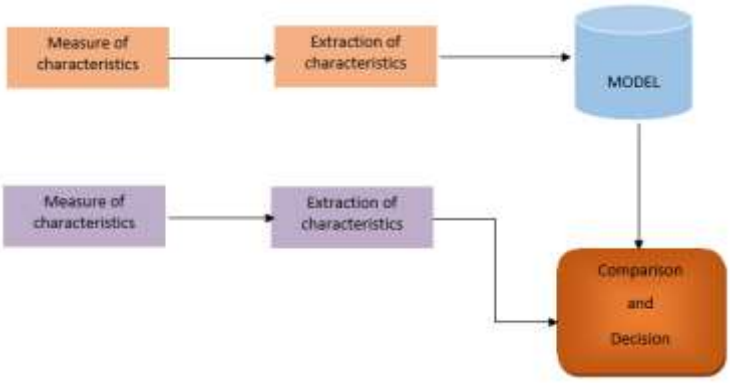

Fig -1: Architecture of a system of a handwritten signature recognition.

The aim of the learning module is to create the model that serves as a reference [2]. While the comparison module compares the acquired signature with the model by providing a result. A system of a handwritten signature recognition has two modes of operation depending on the result of the comparison module. We have the authentication whose result concerns the 1: 1 problem, that is, the result is either accepted or rejected. We have the identification that returns a list of results, namely the resolution of the problem 1: N.

The acquisition of a signature can be online "on-line" or offline "off-line". The acquisition in offline mode is generally done by scan while the online acquisition is done by a digital tablet and a stylus [1]. The difference lies in the possible acquisition of the dynamic characteristics for the online mode.

Extraction of features comes in two stages, including preprocessing of the signature and extraction of the features itself.

3. SYSTEM DETAILS AND EVALUATION

The designed system can process an identification and authentication.

3.1 Acquisition

The system is for an online approach. The acquisition process occurs through the process of writing on the tablet, by capturing and recording in a digital image medium (Fig-2).

Fig -2: Procurement process.

3.2 Pretreatment

To extract the characteristics of the signature, pretreatment is essential. The pretreatment process receives as input the captured image from acquisition, it passes for processing and will be stored again (Fig-3).

Fig -3: Treatment process.

3.3 Extraction

Two types of features are considered namely the dynamic and static characteristics (Fig-4). The Dynamics characteristics are already obtained during the acquisition. Features are extracted after pre-treatment (Table-1).

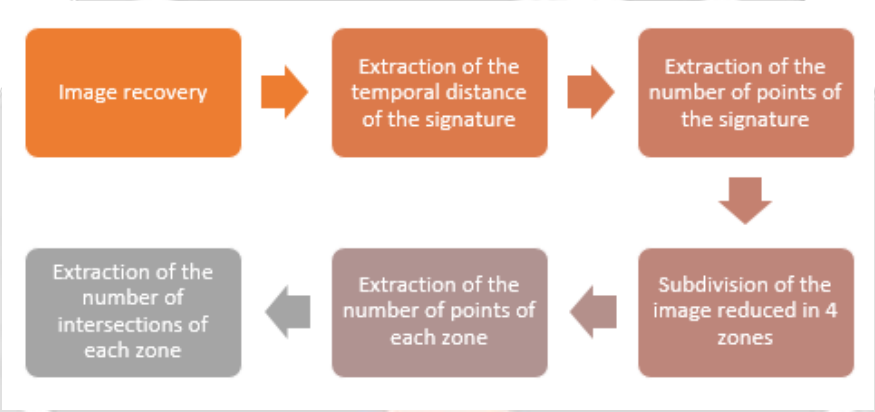

Fig -4: Extraction process

Table -1: List of characteristics of a signature

Features	Descriptions	Note
Pt_s	Set of points of the signature	
T_s	Total duration of the signature	in s
L_s	Length of the signature	in number of pixels
l_s	Width of the signature	
Np_s	Total number of signature points	in number of pixels
Z_m	Image area	1/4 of the image following the width
$Np_s(Z_m)$	Number of points in the area Z_m	
$Np_s(Z_m)$	Number of intersections in the area Z_m	

A signature is represented by a set of points at time t [3].

$$\mathrm{Pt_s} = \{\mathrm{pt_1}, \mathrm{pt_2}, \ldots, \mathrm{pt_n}\} \quad (1)$$

With $pt_i = (x_i, y_i, t_i)$, point to i.

The time distance between the time of the initial point $\mathrm{t_1}$ and the last point $\mathrm{t_n}$ is one of the features to be extracted.

$$\mathrm{T_s} = \mathrm{dist}(\mathrm{t_1}, \mathrm{t_n}) \quad (2)$$

The length L_s and the width l_s of the signature are essential features.

$$L_s = dist(x_{min}, x_{max}) \quad (3)$$

The total number of points in a signature is different from one individual to another. So, we can take it as a relevant feature

$$Np_s = n - 1 \quad (4)$$

n is the index of the last point.

Details of the signature can be considered by subdividing the image into four zones Zm.

$$Z_m = \left[m\frac{l_s}{4}\right] \quad (5)$$

m=1,2,3,4

For each zone we can calculate the number of points Np_s.

$$Np_s(Z_m) = n(Z_m) - 1 \quad (6)$$

From each area, we can also define the number of intersections Ni_s

$$Ni_s(Z_m) = \mathrm{card}(\{\mathrm{ni} / \tfrac{l_s}{4} \cap \mathrm{S_k}\}) \quad (7)$$

3.4 Model creation (Learning module)

After the extraction of the characteristics, one proceeds to the creation of the model which gathers the data representative of the individual by his signature [2]. The creation of the model serves to store the features extracted in a database.

$$\mathrm{SM_k} = \{\mathrm{T_{sm}}, \mathrm{L_{sm}}, \mathrm{l_{sm}}, Np_{sm}, Np_{sm}(Z_{sm}), Ni_{sm}(Z_{sm})\} \quad (8)$$

3.5 Comparison (Comparison module)

The comparison step implements an algorithm that makes it possible to compare one by one the characteristics of the signature to be recognized with those of the model. To allow the decision, a margin is defined for each feature of the model (Table-2). If the features are in the corresponding margins to the properties of the model, one or more results are obtained (according to the mode of operation of the system).

Table -2: Margin for each model property

Property of the model	Margin
Total time	$M_T = [T_{sm} - \tau_T, T_{sm} + \tau_T]$
Length	$M_L = [L_{sm} - \tau_L, L_{sm} + \tau_L]$
Width	$M_l = [l_{sm} - \tau_l, l_{sm} + \tau_l]$
Total number of points of the entire signature	$M_{Np} = [Np_{sm} - \tau_{Np}, Np_{sm} + \tau_{Np}]$
Total number of signature points by area	$M_T = [Np_{sm}(Z_{sm}) - \tau_{Np_{sm}(Z_{sm})}, Np_{sm}(Z_{sm}) + \tau_{Np_{sm}(Z_{sm})}]$
Number of intersections by area	$M_T = [Ni_{sm}(Z_{sm}) - \tau_{Ni}, Ni_{sm}(Z_{sm}) + \tau_{Ni}]$

With τ is a number obtained by experience

For the comparison algorithm, compare first the duration then the length, then the width, the number of points of the whole signature, the number of points by area and finally the numbers of intersections by areas (Fig-5).For authentication, if we get a positive or negative result, the algorithm is terminated, otherwise the hand comparison is repeated by swapping the rank of the characteristics and so on until all the characteristics are permuted. For authentication the result is either accepted or rejected.

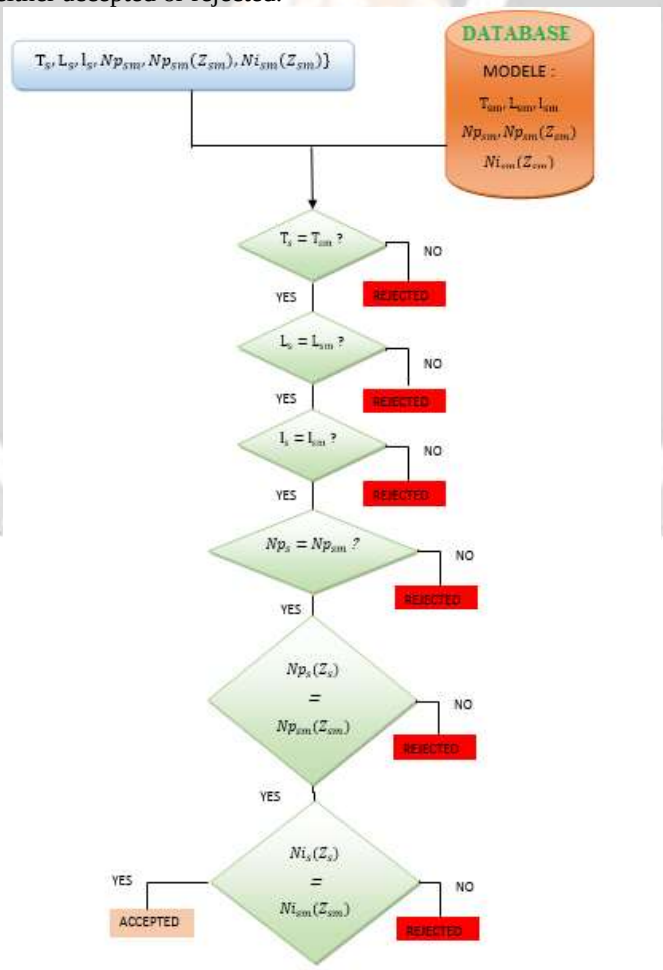

Fig -5: Comparison process for authentication

For an identification, if one has a negative result in each comparison of features, we change signature otherwise continue the comparison. Finally, the system returns a result list representing all the signatures in the vicinity of the signature to be identified (FIG. 6).

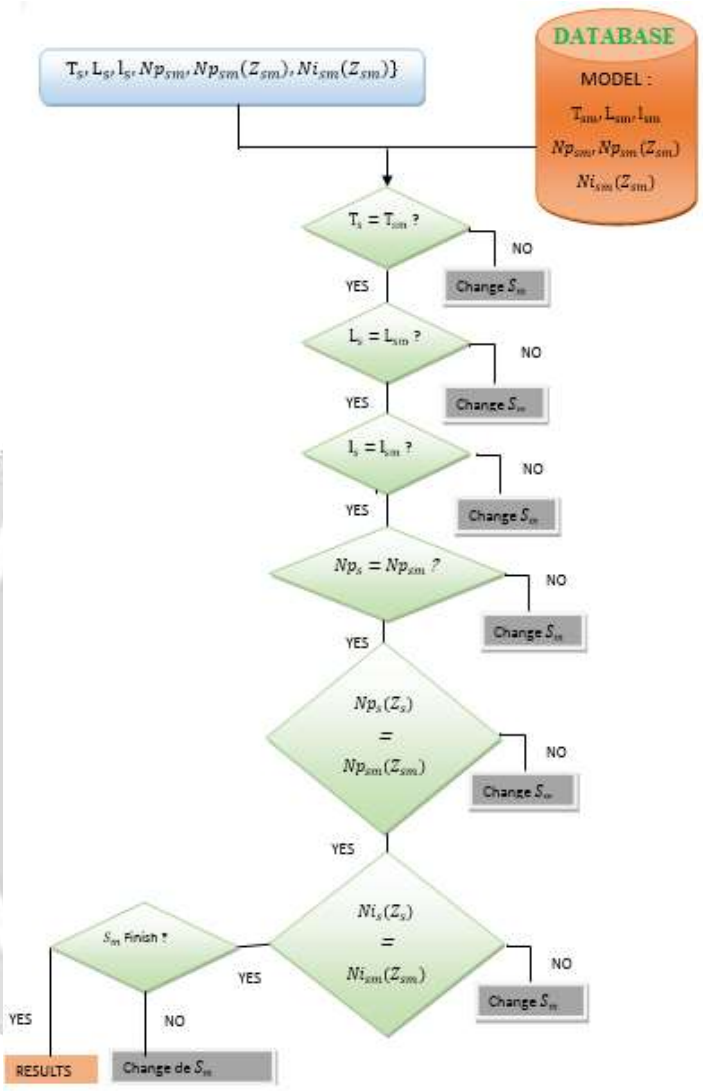

Fig -6: Comparison process for identification

3.6 Evaluation and performance

The performance of a handwriting recognition system is measured by the false acceptance rate (FAR) and the false rejection rate (FRR). It is reflected respectively by false acceptance rate and that of the false rejection rate and by the proportion of correct individuals rejected.

$$FAR = \frac{FA}{NI} * 100 \ (en\ \%) \tag{9}$$

$$FRR = \frac{FR}{NL} * 100 \ (en\ \%) \tag{10}$$

To have an efficient system the FAR should be equal to the FRR, this is what is meant by EER or "Equal Error Rate" [1] [4].
For evaluation of the system, 10 models were created for 10 individuals. Each individual has a reference in the database. For each individual 10 false and 10 true were tested for a FAR of 0.2% and a FRR of 0.1% that is to say one has a FAR> FRR. Having a FAR equal to FRR is a bit difficult, but having a FRR> FAR is acceptable in the opposite case.

Table -3: Extract from test results on real signatures

Duration	Length	Width	nbPoint	NbInter	TA/TR
5	148	93	339	17	TA
32	275	105	689	13	TR
5	153	88	338	19	TA
5	149	95	345	16	TA
4	148	93	344	18	TA
5	138	88	351	17	TA
4	167	109	347	19	TA
4	162	89	401	18	TR
4	154	100	358	18	TA
5	158	90	376	19	TA

TA: True Accepted; TR: True Refused

Table -4: Extrait de résultats de tests sur des fausses signatures

Duration	Length	Width	nbPoint	NbInter	FR/FA
4	145	94	338	18	FR
5	171	160	441	14	FR
9	152	83	532	19	FR
8	200	99	595	19	FR
5	183	148	480	17	FR
5	98	48	304	13	FA
12	166	117	716	18	FR
4	196	146	334	12	FR
5	192	88	386	8	FR
4	64	139	261	3	FR

FR : False Refused ; FA : Faux accepted

4. CONCLUSIONS

A handwritten signature recognition system makes it possible to authenticate or identify an individual. A handwritten signature has features that are unique from one individual to another. By image processing and use of mathematical presentations, these features can be exploited to create a model and to make a comparison between the model and the signature to be recognized. A system was designed with a FAR of 0.2% higher than the FRR of 0.1%. Theoretically for a reliable system it is necessary to have an EER where the FAR is equal to EER. Practically it is difficult to realize the theory, but to have a FRR> FAR is acceptable compared to the opposite case. Nevertheless, improvements can be envisaged on the learning module side than on the comparison module side.

5. REFERENCES

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