Towards new biomarkers based on dynamic biometric pattern analysis

BiDA-Lab
Biometrics and Data Pattern Analytics

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Abstract

The human body is constantly communicating **information** about our **health**. This information can be captured and processed to model the **cognitive and neuromotor** health of the users. Traditionally, such measurements are taken manually by Physicians during **isolated visits**. **Biometric signal processing** involves the analysis of these measurements to provide useful information upon which clinicians can make decisions. Engineers are discovering new ways to process these signals using a variety of **sensors** and new **artificial intelligence** algorithms. It is time to redefine some of the traditional **biomarkers** to exploit such a new technology capabilities.

Artificial Intelligence and Health: Are we exploiting nowadays technology capabilities?

1st Generation (1990~): **Basic Methods** – PCA,LDA,…

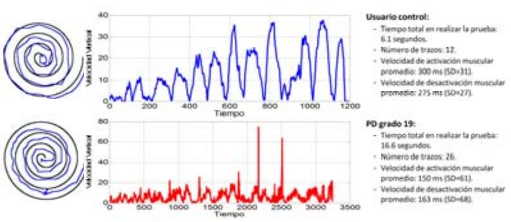
2nd Generation (2000~): **Linear Subspace Methods** – Sparse Representation, Metric Learning

3rd Generation (2010~): **Non-Linear Methods** – Deep Learning

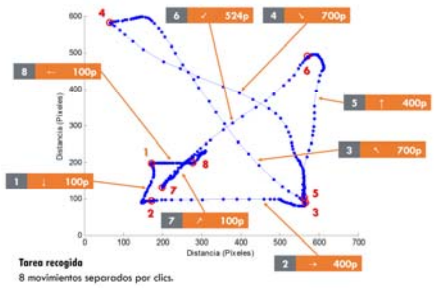
Figure 1. Evolution of pattern recognition algorithms

Biometric dynamic patterns based on user interaction

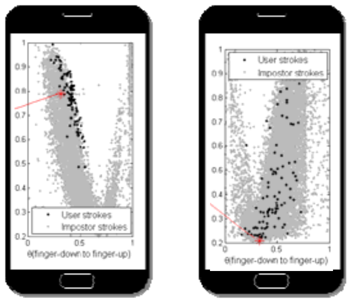
Handwriting dynamics: The handwriting is a **behavioural biometric** trait which comprises **neuromotor** characteristics of the user (e.g. our brain and muscles among other factors define the way we write) as well as **socio-cultural** influence (e.g. the Western and Asian styles). The dynamics of handwriting include **rich patterns** related with velocity, acceleration or angular information, among others.



Mouse dynamics: Mouse dynamics are derived from the user-mouse **interaction**. The mouse trajectories include information related with **neuromotor capabilities** of the user that can be derived from velocity profiles and **precision**. There is a large room for research focus on the development of specific task to reveal the user state.



Touch dynamics: The great popularity of **smartphones/tablets** and the increase in their use in everyday applications has led to develop new applications based on touch interactions with the screens. **Keystroking, handwriting or mouse** have been replaced by simple touch actions.



Analysis of biometric dynamic sequences: Sigma-Lognormal model

The Sigma-Lognormal model states that the velocity profile of human hand movements can be decomposed into strokes. Moreover velocity of each of these strokes, i, can be described with a speed signal $\vec{v_i}(t)$ that has a lognormal shape.

$$|\vec{v_i}(t)| = \frac{D_i}{\sqrt{2\pi\sigma_i(t-t_{0_i})}} \exp\left(-\frac{\left(\ln\left(t-t_{0_i}\right)-\mu_i\right)^2}{2\sigma_i^{\,2}}\right)$$

Where each of the parameters are described in Table 1. The complete velocity profile is modelled as a sum of the different individual stroke velocity profiles as:

$$\vec{v_r}(t) = \sum_{i=1}^{N} \vec{v_i}(t)$$

Where N is the number of lognormals of the entire movement.

Table 1. Sigma Lognormal parameter description.

Parameter	Description
D_i	Input pulse: covered distance when executed isolated.
t_{0i}	Initialization time. Displacement in the time axis.
μ_i	Logtemporal delay.
σ_i	Impulse response time of the neuromotor system.
θ_{si}	Initial angular position of the stroke.
θ_{ei}	Final angular position of the stroke.

Sensor → **Feature Extraction** → **Classification**

[1] R. Tolosana, R. Vera-Rodriguez, J. Fierrez, A. Morales and J. Ortega-Garcia, "Benchmarking Desktop and Mobile Handwriting across COTS Devices: the e-BioSign Biometric Database", *PLOS ONE*, Vol. 5, n. 12, 2017.
[2] M. A. Ferrer, M. Diaz-Cabrera, C. Carmona-Duarte, A. Morales, "A Behavioral Handwriting Model for Static and Dynamic Signature Synthesis". *IEEE Trans. on Pattern Analysis and Machine Intelligence*, Vol. 39, no. 6, pp. 1041-1053, June 2017.
[3] M. Martinez-Diaz, J. Fierrez and J. Galbally, "Graphical Password-based User Authentication with Free-Form Doodles", *IEEE Trans. on Human-Machine Systems*, IEEE, Vol. 46, n. 4, pp. 607-614, August 2016.