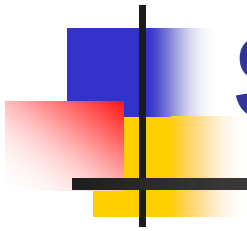
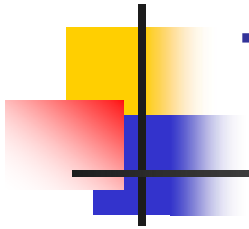


Signature recognition



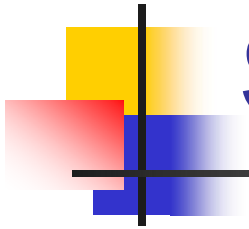
Topics

- Definitions
- Feature extraction
- Signature Forgery
- Signature models
- Advantages and disadvantages of signature as biometrics

Signature

Static off-line technology – document authentication

Dynamic on-line technology – signal processing and pattern recognition

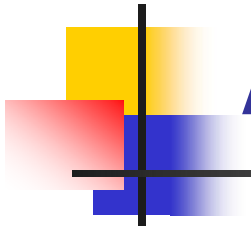


Signatures

- **Off-line** or **static** signatures are scanned from paper documents, where they were written in conventional way. Off-line signature analysis can be carried out with a scanned image of the signature using a standard camera or scanner.
- **On-line** or **dynamic** signatures are written with an electronically instrumented device and the dynamic information (pen tip location through time) is usually available at high resolution, even when the pen is not in contact with the paper.

PDA

Signature in Identity Documents

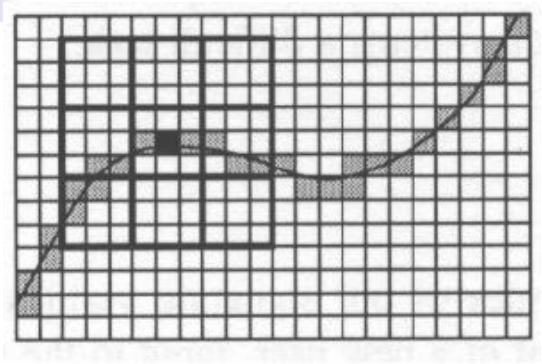


Automatic identification

- Traditional means of automatic identification:
  - **Possession-based** (credit card, smart card)
    - Use “something that you have”
  - **Knowledge-based** (password, PIN)
    - Use “something that you know”
  - **Biometrics-based** (biometric identifier)
    - Use something that relies on “what you are”

- Signature is inherently a combination of knowledge and biometric, the knowledge component (what is written and how it is written) can be chosen, and indeed changed, by the user

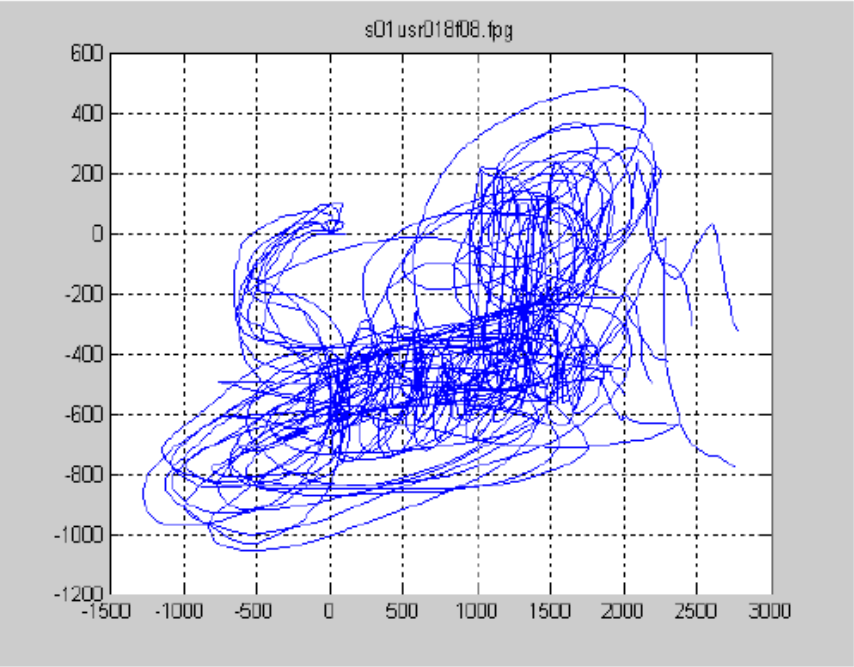
Pre-processing



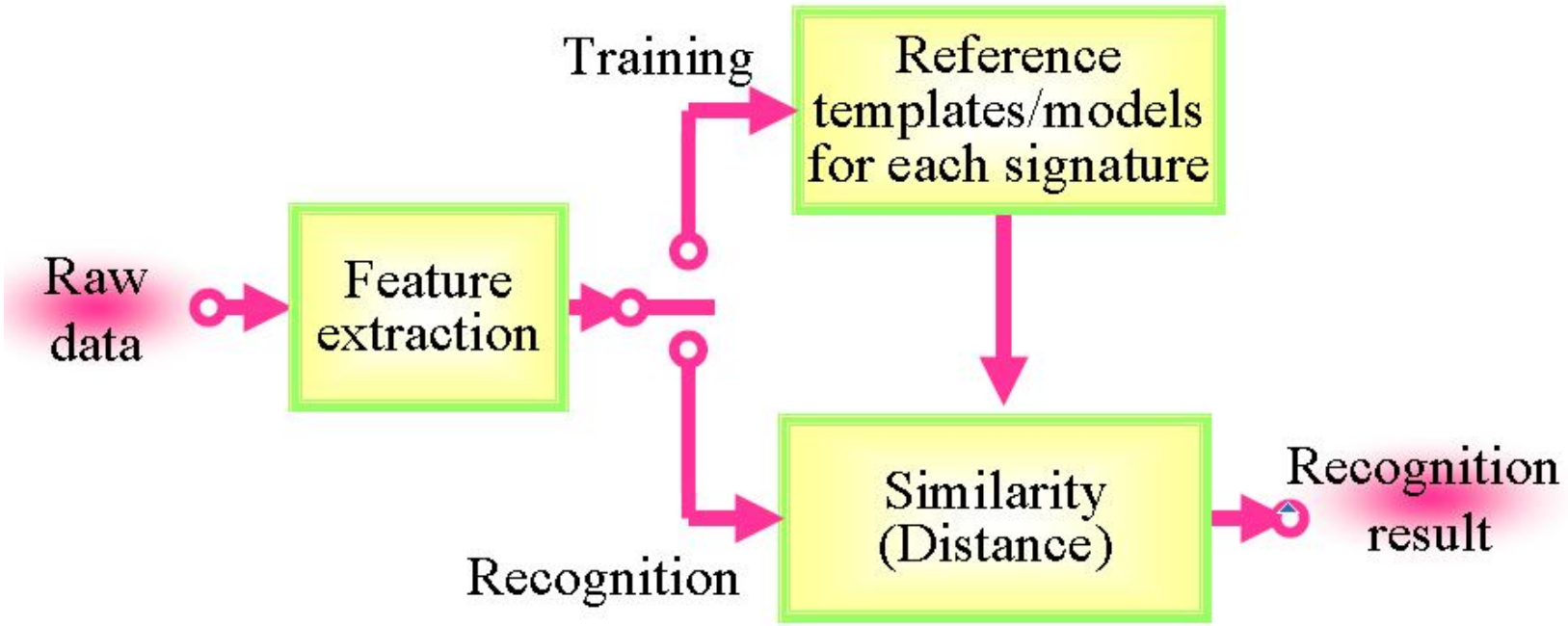
- **Smoothing:** the input signal from a digitizing pen can be very jagged. The pen used can affect the smoothness and the size of the signature.
- **Segmentation:** determination of the beginning and ending of signing.
- **Signature beginning:** first sample where pressure information is not null (first pen-down)
- **Signature ending:** last pen-up. Because few pen-ups can be found in the signature, we have to establish a maximum pen-up duration (e.g. 3 s).

Pre-processing

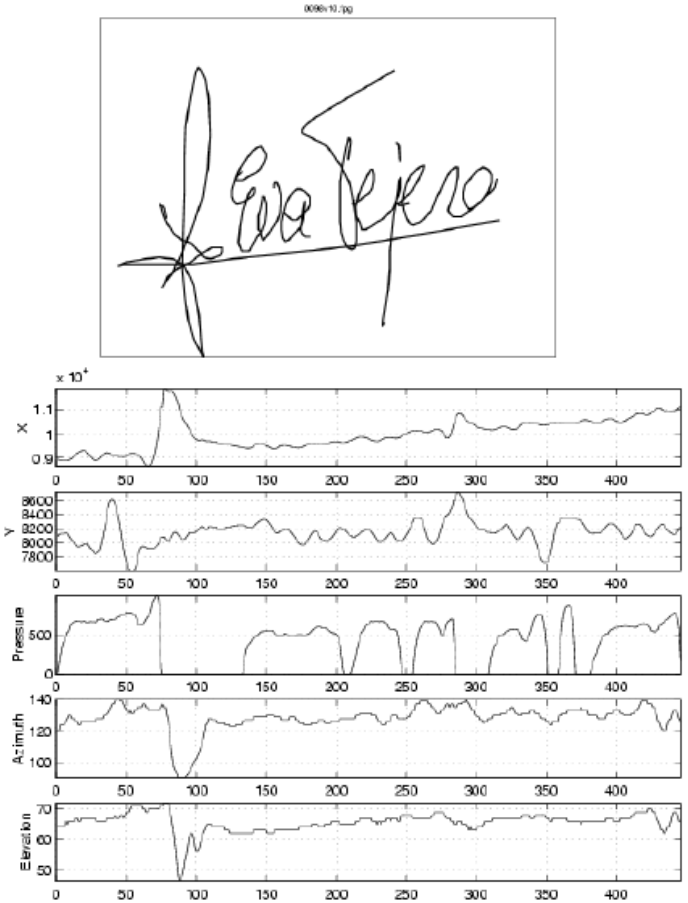
Initial point alignment: all the signatures have to be aligned with respect to the initial point (e.g. the coordinate origin) to make information independent from the position on the tablet.

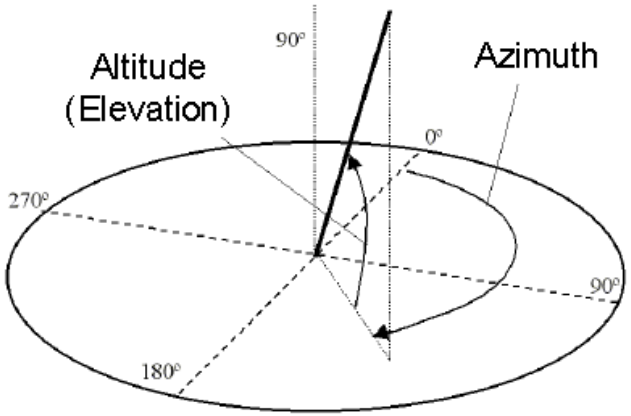


Principal structure of signature recognition systems



Dynamic Signature

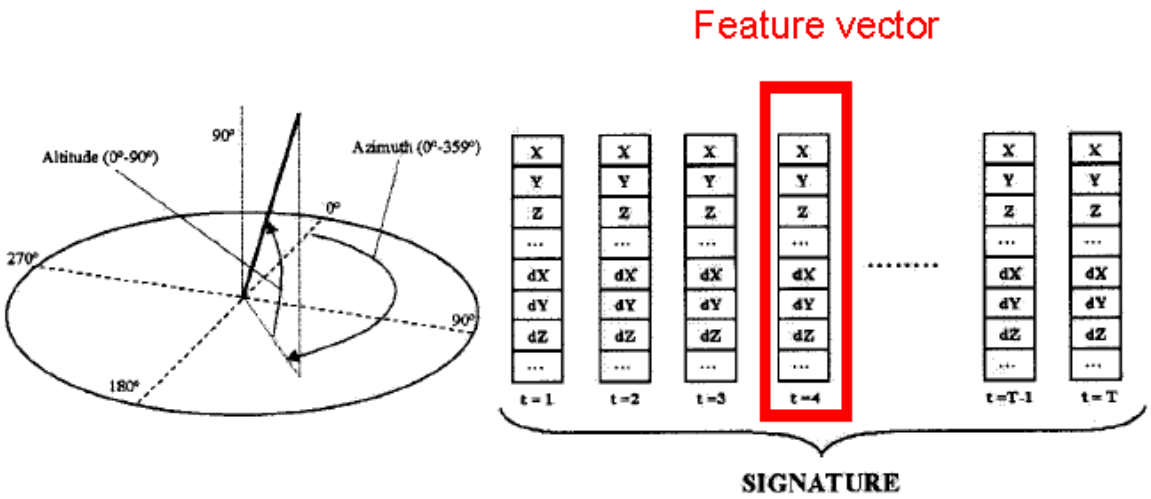




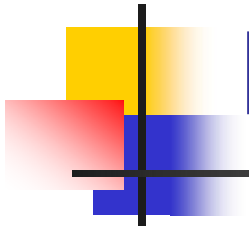
Features:

1. coordinate X
2. coordinate Y
3. pressure
4. pen azimuth (0° - 359°)
5. pen altitude (0° - 90°)

Feature vectors -Template



- acquisition area: 127·106 mm
- pressure levels: 1024
- resolution: 2540 lines/inch (100 lines/mm)
- precision: +/-0.25 mm
- detection height: 10 mm
- sampling frequency: 100 pps (points per s)



Local and Global Features

- **Local features**
  - x, y coordinates
  - Velocity (v)
  - Acceleration (A)
  - Trajectory angle (Θ)
  - Azimuth
  - Elevation
  - First derivative of feature (Δ)
  - Second derivative of feature (ΔΔ)

Local and Global Features

- **Global features**
  - Signature length, height, weight
  - Total signature time
  - Total pen-down time
  - Total pen-up time
  - Average velocity
  - Maximum velocity
  - Minimum velocity
  - –etc,.

Examples of local features

- Derivative functions are approximated by second order regressions instead of differences between consecutive samples. The general expression of the order *N* regression calculated in the instant *t* for parameter *q* is:

$$\mathrm{reg}(q_t, N) = \frac{\sum_{\tau=1}^{N} \tau (q_{t+\tau} - q_{t-\tau})}{2\sum_{\tau=1}^{N} \tau^2}$$

- Then, velocity and acceleration for parameter *q* at instant *t* can be computed as

$$\Delta_{q_t} = \dot{q}_t = \mathrm{reg}(q_t, 2)$$

$$\Delta\Delta_{q_t} = \dot{\Delta}_t = \mathrm{reg}(\Delta_t, 2)$$

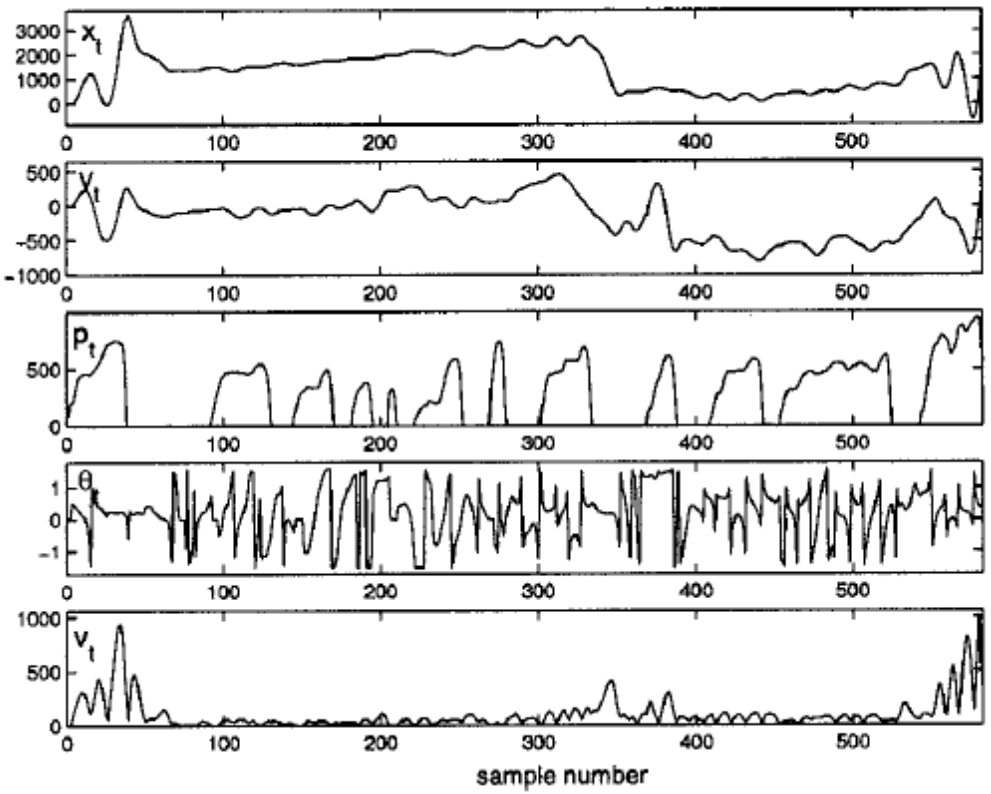
Examples of local features

Trajectory angle

$$\Theta_t = \arctan\left(\frac{\dot{y}_t}{\dot{x}_t}\right)$$

Velocity

$$v = \sqrt{\dot{x}_t^2 + \dot{y}_t^2}$$

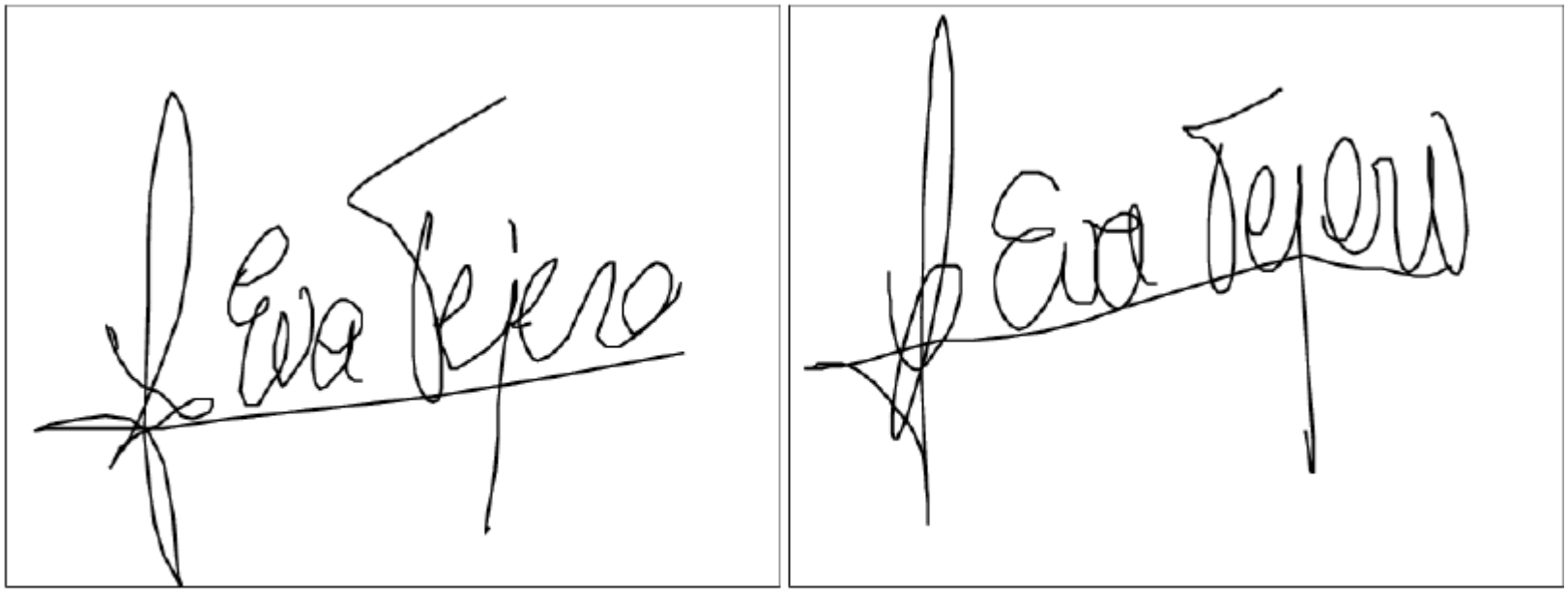


Forgery

Genuine signatures

Forgery signatures

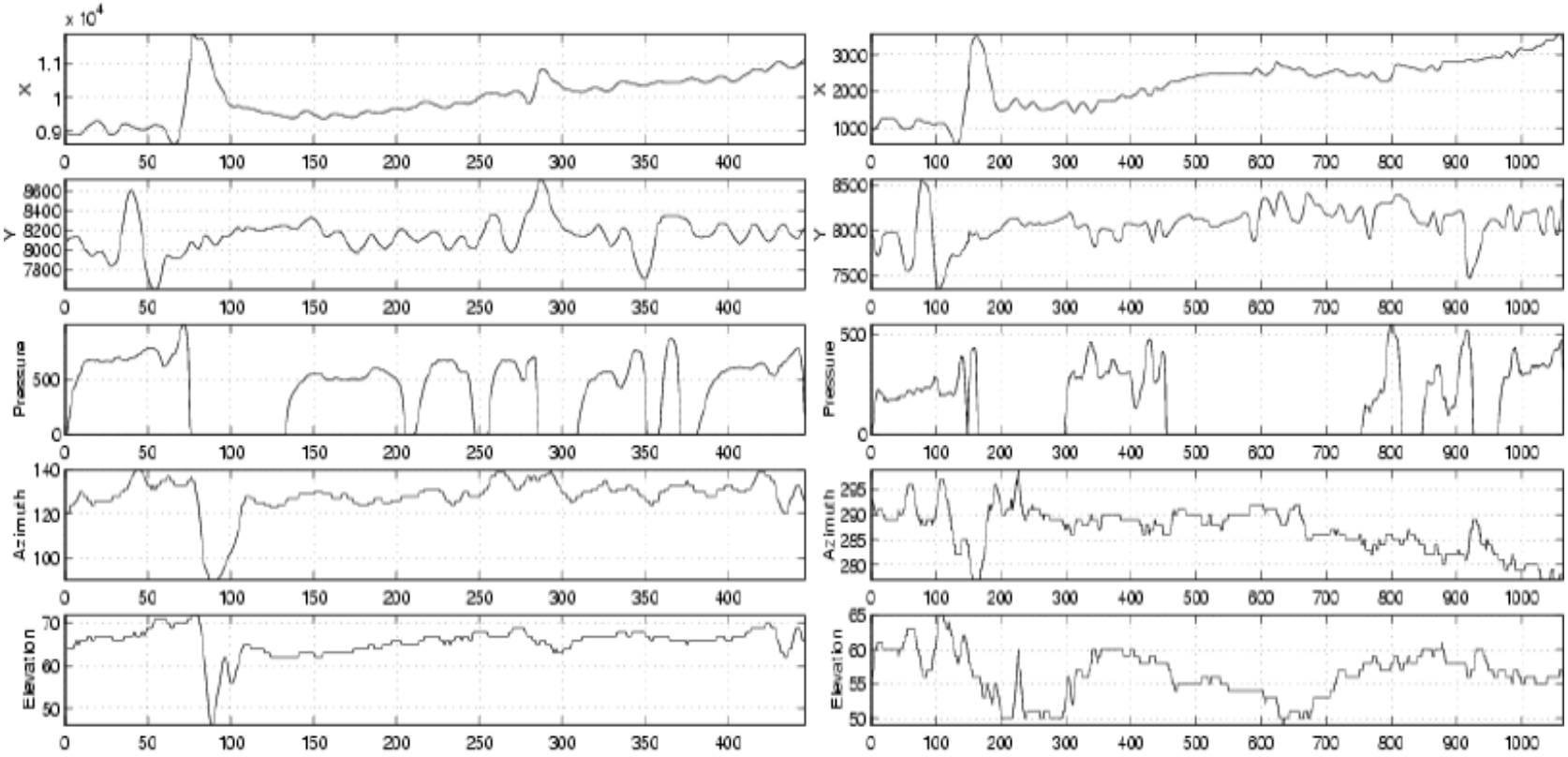
Signatures: authentic and skilled forgery



Authentic signature

Skilled forgery

Features


x 10^4
X
Y
Pressure
Azimuth
Elevation
Authentic signature
Skilled forgery

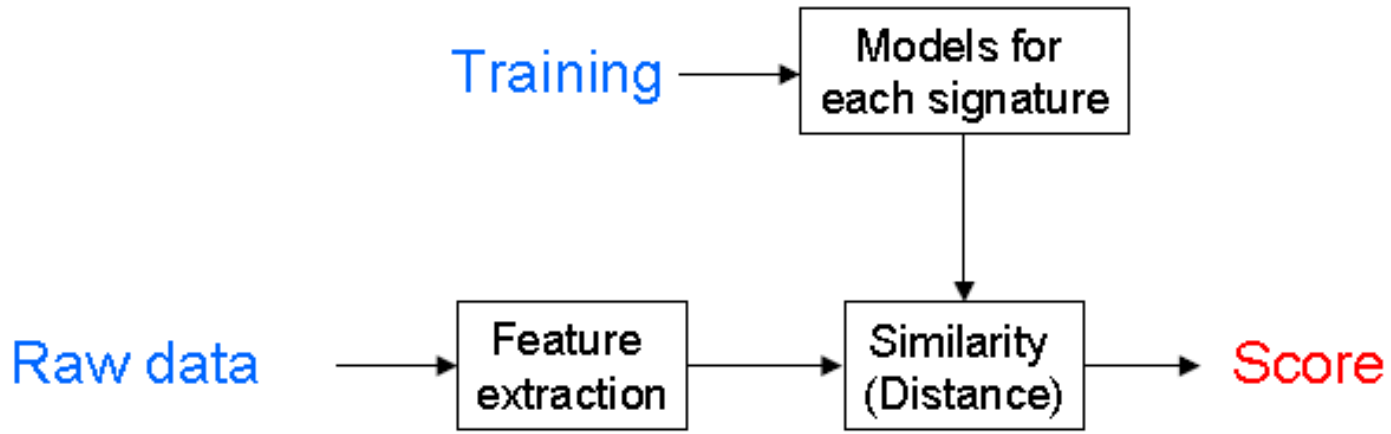
Models in Signature Recognition

Statistical Methods

- Gaussian Mixture Model
- Hidden Markov Model

Deterministic Methods

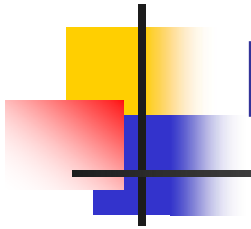
- Dynamic Time Warping
- Vector Quantization



Signature Recognition Advantages

- Signature is a man-made biometric where forgery has been studied extensively
- Enrollment (training) is intuitive and fast
- Signature verification in general has a fast response and low storage requirements
- A signature verification is “independent” of the native language user
- Very high compression rates do not affect shape of the signature (100-150 bytes)

Signature Recognition Disadvantages



- There is much precedence for using signature to authenticate documents and not for security applications
- A five-dimensional pen may be needed to arrive at the desired accuracy. This makes the hardware costly.
- Some people have palsies, while others do not have enough fine motor coordination to write consistently