Berrin Yanikoglu and Alisher Kholmatov "Online Signature Verification Using Fourier Descriptors" in EURASIP Journal on Advances in Signal Processing. Volume 2009.

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Outline

Online signature verification

- Consider a signature with dynamic information such as position x, y, pen pressure p, along a trajectory in time t.
- Users enroll in the system by providing several reference signatures.
- Then a new query signature is compared against the references. If the disimilarity is above a certain fixed threshold, the user is rejected.
- Many global and local pattern recognition schemes can measure signature similarity. We will examine a global method based on the Fourier Transform.

Signal pre-processing

- An online signature can be defined as $S \in \mathbf{R}^{N \times 4}$ where each sample

$$S(n) = \begin{bmatrix} x(n) & y(n) & p(n) & t(n) \end{bmatrix} \quad \text{for } n = 1, \ldots N$$

  contains position $x(n), y(n)$, pressure $p(n)$, and timestamp $t(n)$.

- Typical sample rate is 100 Hz. No data is collected during pen-up periods, *i.e.*, pen is not touching the pad.

- Pen-up periods can help discriminate between valid and forged signatures. For time periods $t(n+1) - t(n)$ greater than 10ms, add a new sample every 30ms using mid-point interpolation. Now the timestamp is redundant and discarded.

- Drift and mean removal centers the signature to make it invariant.

- Zero-pad signal length to use same number of samples N.

Fourier feature extraction

- We now convert the pre-processed signal into frequency space via the Discrete Fourier Transform

$$c_k = \sum_{t=0}^{N-1} f(t) e^{-i2\pi kt/N} \quad \text{for } k = 0, \ldots N-1$$

  where the function $f(t)$ can be composed of any combination of $x \mid y \mid p$.

- The first coefficient c_0 is discarded for translation invariance.

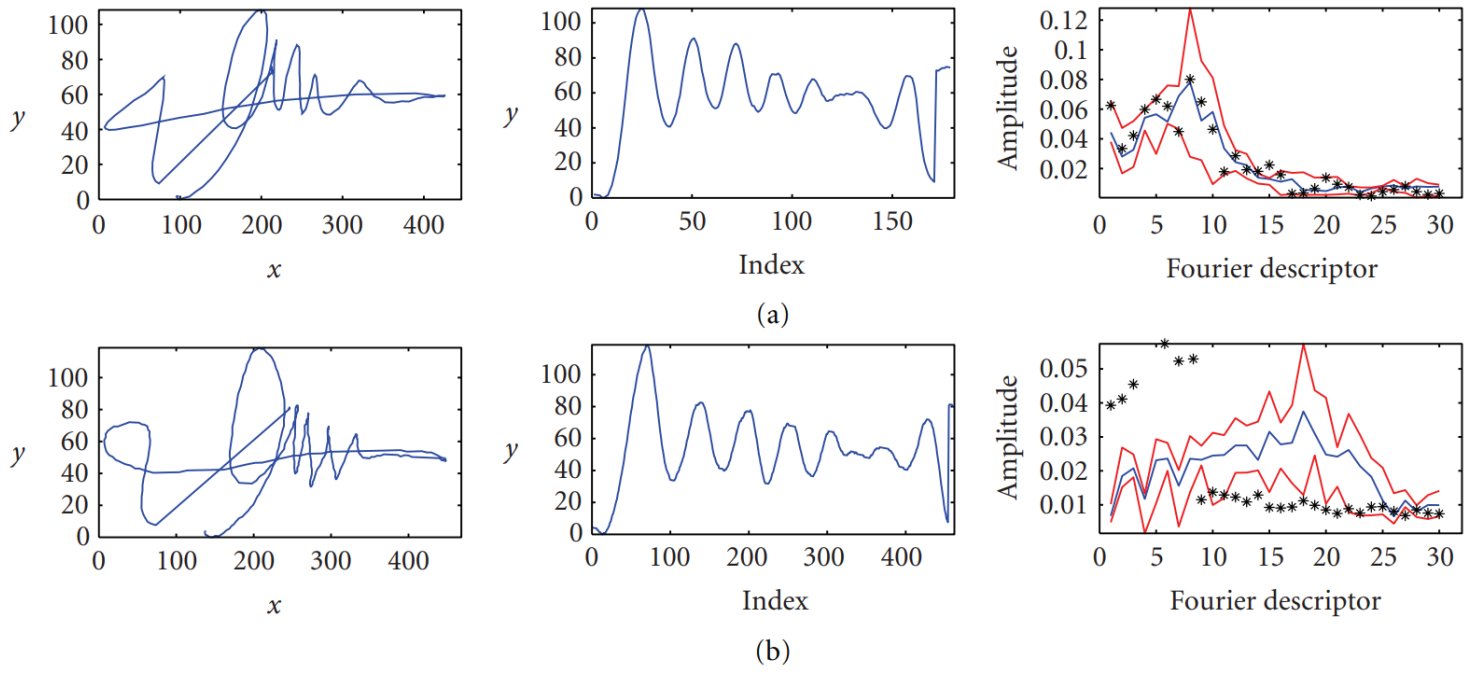
- Then all other coefficients are normalized by the spectrum magnitude

$$F_k = \frac{|c_k|}{\|c\|} \quad \text{for } k = 1, \ldots N/2$$

  only half the spectrum is used because it's symmetric.

- Finally smooth F by averaging each coefficient with its neighbor.

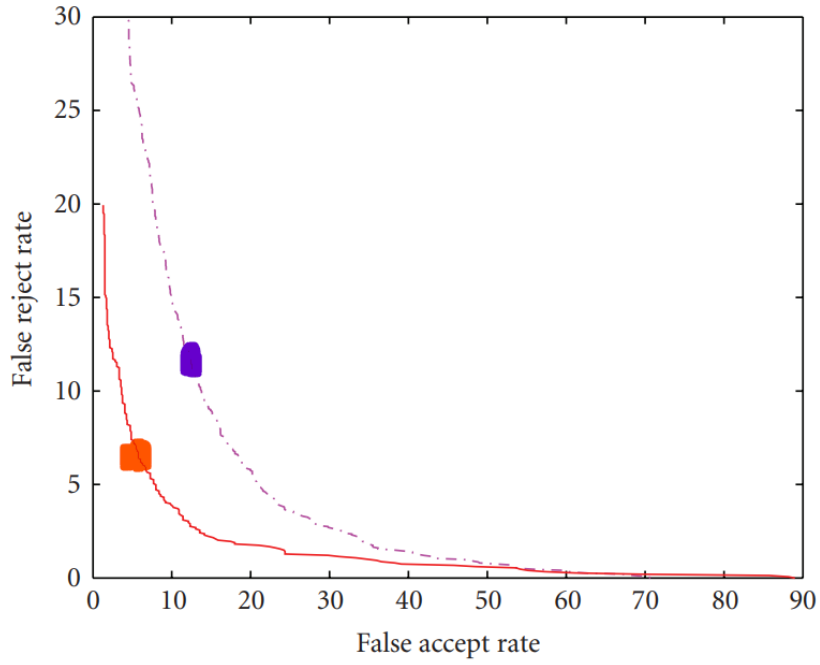
Query reference matching



- Matching between query q set of reference signatures R_i for user i is done by measuring the Euclidean distance between the respective Fourier coeffcients

$$d(q, R_i) = \|F_q - F_{R_i}\|.$$

Experimental Results



- Tested using open source databases SUSIG and MCYT.
- Just using positional information yields equal error rates (EER) 6.2% and 14.5% respectively.
- Including pressure, azimuth, and altitude information from MCYT improves EER to 12.1%.

Outline

Intellectual Merit

- Strengths
  - This group won a world wide competition using a different method (Dynamic Window Timing). Presenting an additional method using the Fourier Transform shows this group's strength.
  - Combining their award winning DWT with the Fourier method improves accuracy.
- Weaknesses
  - Paper structure is confusing. While describing the method, they list all possible ways to process the signal. Hard to explicitly pick out the recipe.
  - The verification case figure is confusing because the (a) and (b) figures should have the same reference bounds, but the figure shows them as different.

Broader Impact

- Strengths
  - Compared against other studies using Fourier Transform.
  - Carefully analyzed all pre-processing steps to keep to a minimum.
  - Pattern recognition is a finicky subject. The authors note that while one method may work well on one database, it may not perform as well on another.