Signature Verification Using DTW

Third Group Task

1 Introduction

Handwritten signatures are widely used for identity verification. Unlike offline signatures, online signatures provide dynamic information such as pen trajectory, velocity, and pressure, which improves resistance to forgery. The objective of this project is to verify whether a given signature is genuine or forged using a DTW-based matching approach.

2 Dataset Description

The MCYT dataset contains online handwritten signatures collected from 30 writers. For each writer, the dataset includes:

- **5 enrollment signatures**, all of which are genuine,
- **45 verification signatures**, composed of:
  - 20 genuine signatures,
  - 25 skilled forgeries.

The dataset is organized into two main folders:

- **enrollment/**, containing the 5 genuine reference signatures per writer,
- **verification/**, containing the 45 verification signatures (genuine and forgeries).

The file `gt.tsv` provides the ground truth labels for all verification signatures, indicating whether each sample is genuine or forged.

Signature Format Each signature is stored as a TSV file composed of time-ordered samples with the following attributes:

- t: timestamp,
- x: horizontal pen position,
- y: vertical pen position,
- pressure: pen pressure,
- penup: pen up/down state,
- azimuth: horizontal pen angle,
- inclination: vertical pen angle.

Since signatures have variable lengths, direct point-wise comparison using Euclidean distance is not suitable. Therefore, sequence alignment techniques such as **Dynamic Time Warping (DTW)** are required to compare signatures effectively.

3 Methodology

3.1 Feature Extraction

Each signature is represented as a time series composed of spatial coordinates (x, y), pen pressure, and pen velocities:

$$v_x = \frac{\Delta x}{\Delta t}, \quad v_y = \frac{\Delta y}{\Delta t} \tag{1}$$

3.2 Normalization

Each feature is normalized per signature using z-score normalization:

$$f_{norm} = \frac{f - \mu}{\sigma} \tag{2}$$

3.3 Dynamic Time Warping

Dynamic Time Warping is used to align two signatures of variable length. A **Sakoe–Chiba** band with a radius of 10 is applied to constrain the warping path. Each test signature is compared against five reference signatures of the claimed writer.

3.4 Matching Score

The final matching score is defined as the minimum DTW distance obtained between the test signature and the reference signatures:

$$score = \exp(-d_{DTW}) \tag{3}$$

4 Experimental Protocol

The evaluation is conducted under a writer-dependent protocol using:

- 150 enrollment signatures
- 1350 verification signatures
- 5 reference signatures per writer

5 Results

5.1 Performance Metrics

The system achieves the following results:

- Mean Average Precision (mAP): 0.7214
- Area Under the ROC Curve (AUC): 0.8037
- Equal Error Rate (EER): 29.33%

5.2 Confusion Matrix

	Predicted Forgery	Predicted Genuine
Forgery	530	220
Genuine	178	422

6 Discussion

The obtained results indicate good discrimination performance, as reflected by the AUC value. However, the relatively high EER highlights the difficulty of online signature verification, especially in the presence of skilled forgeries.

7 Conclusion

This work presented an online signature verification system based on DTW and dynamic features. Despite its simplicity, the approach achieves competitive performance and serves as a strong baseline for future improvements involving machine learning techniques.