# *Dynamic Signature Verification System Using Stroke Based Features*

Tong Qu

Abdulmotaleb El Saddik

Andy Adler

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# *Outline*

1. Introduction

2. Data acquisition and signature processing

3. Feature extraction methods

4. Feature distribution for signature classifier

5. Signature verification experiments
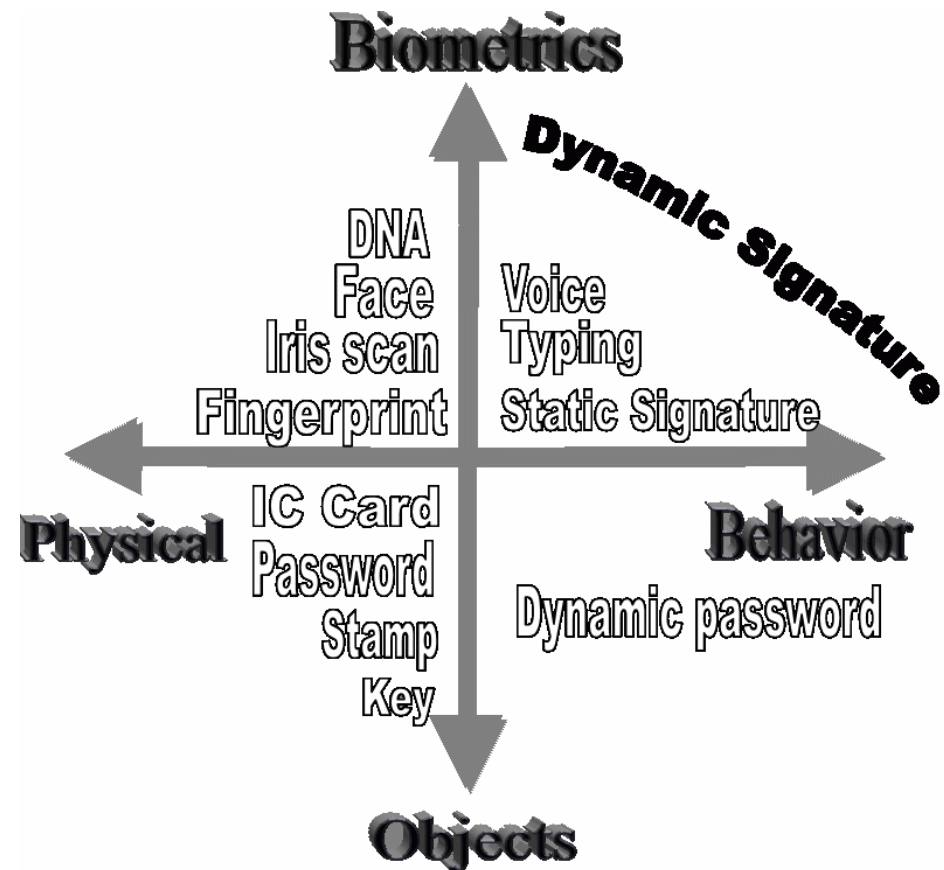
6. Conclusions and future work

# Dynamic Signature Verification in Biometric Techniques
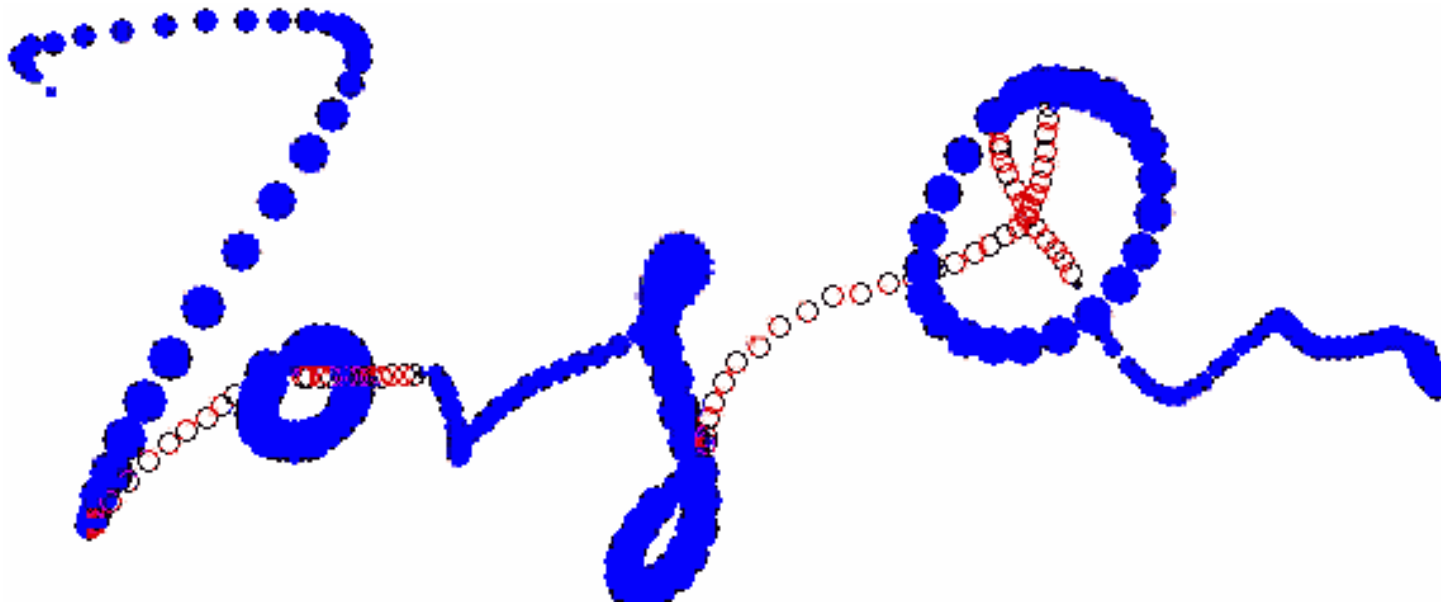
- ➢ A biometric technique for authentication
  - Could replace today's password, pin number etc

- ➢ Application
  - Security
  - Banking
  - E - Commerce
  - Document Management
  - Healthcare
  - …

# *Dynamic signature*



❑ Dot size    = pen pressure
❑ Red Circle  = lifted pen

# *Dynamic Signature Verification*

➢ *Parameters of interest*
- Pen tip velocity and acceleration
- Time between strokes
- Pressure
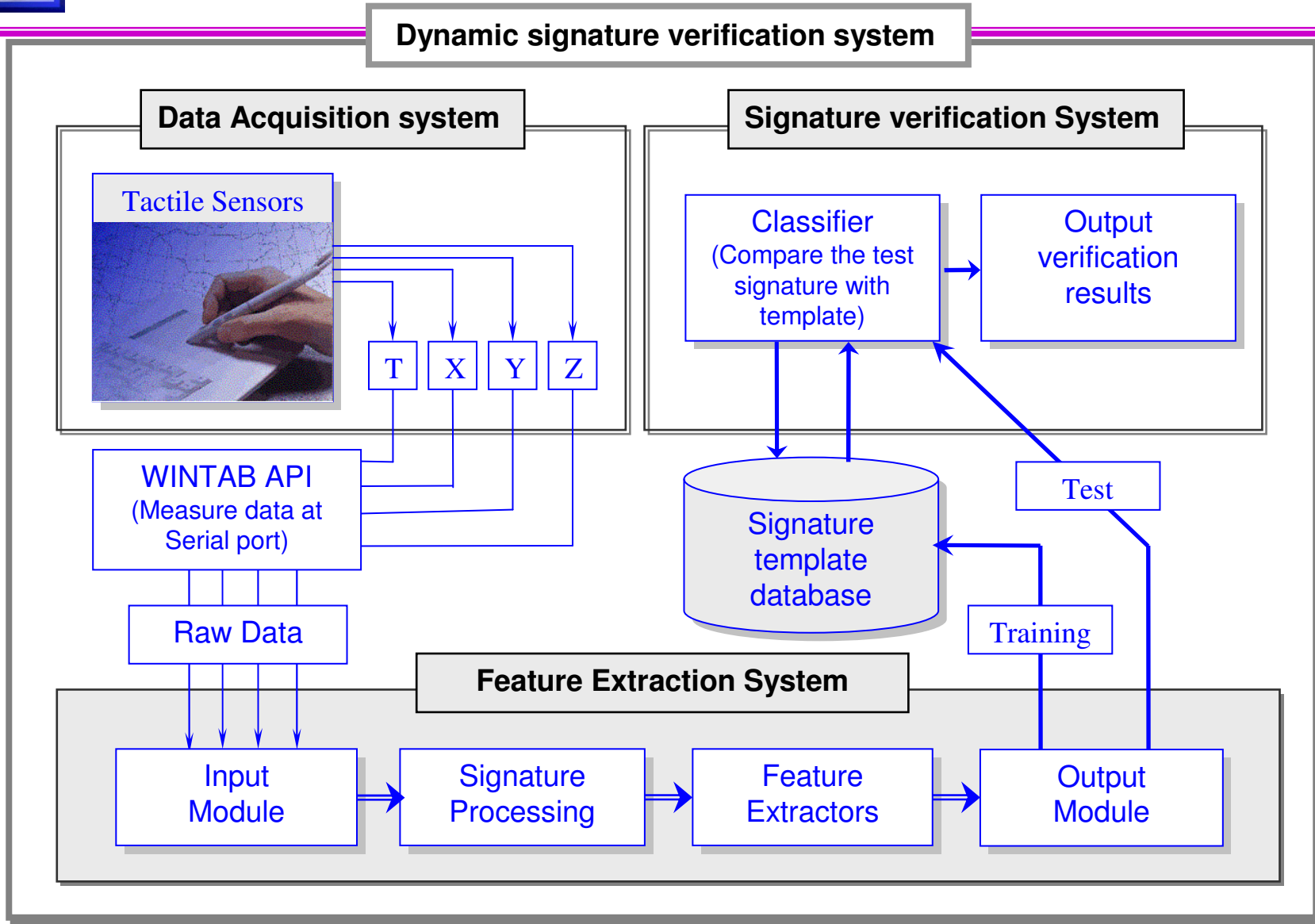- Stroke sequencing
- …

➢ *Advantages*
- Natural and intuitive
- Commonly accepted for authentication
- Less intrusive than iris, fingerprint, etc.

➢ *Related work*
- Time warping
- Euclidian or other distance measure
- Neural network
- ...

# System Architecture

**Dynamic signature verification system**

**Data Acquisition system**

Tactile Sensors

| T | X | Y | Z |

WINTAB API
(Measure data at Serial port)

Raw Data

**Signature verification System**

Classifier
(Compare the test signature with template)

Output verification results

Signature template database

Test

Training

**Feature Extraction System**

| Input Module | Signature Processing | Feature Extractors | Output Module |

# 2. Data acquisition and signature processing

## *Hardware setup*

- Patriot digital pad (tactile sensors)
- WinTablet API
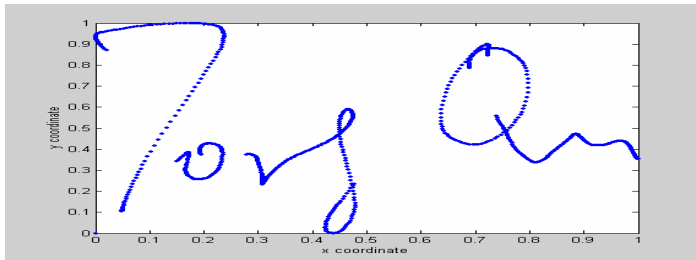- Raw data measured at serial port

## *Implementation*

➢ Custom acquisition
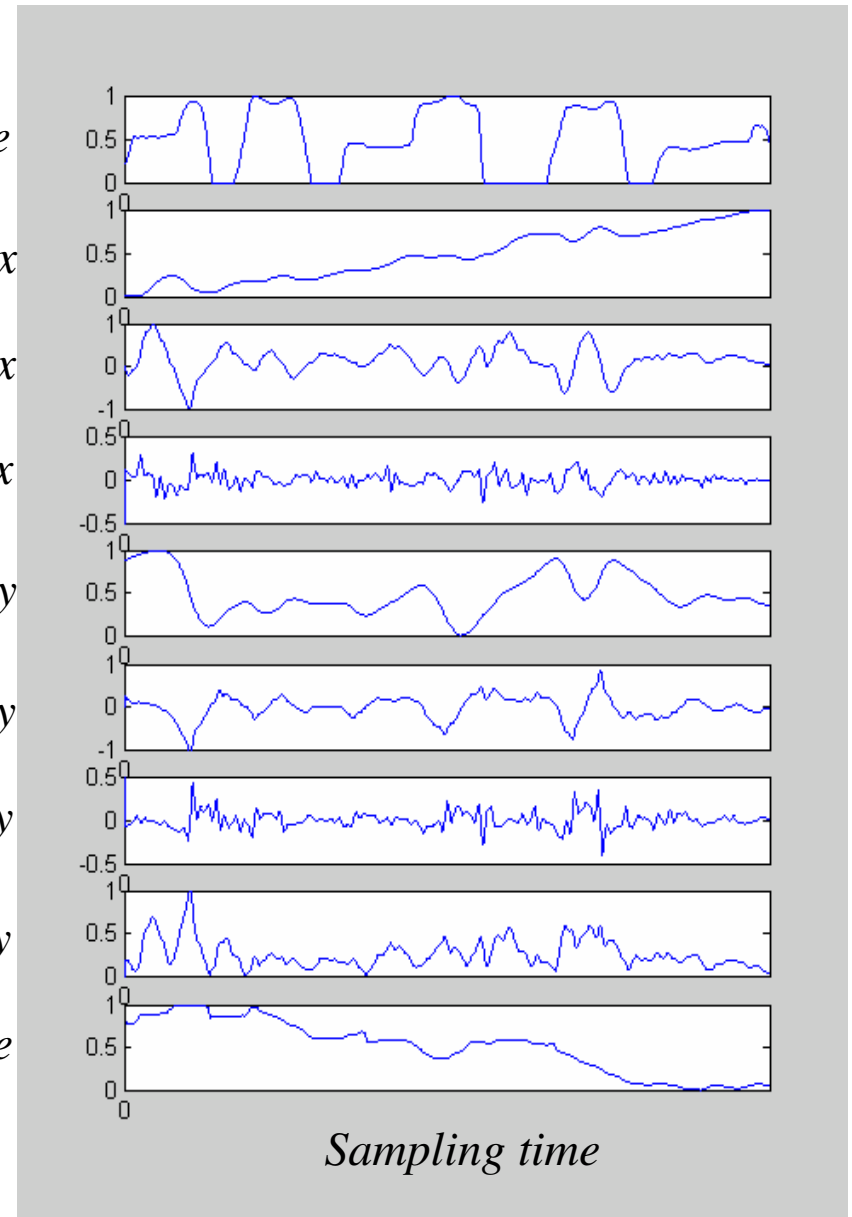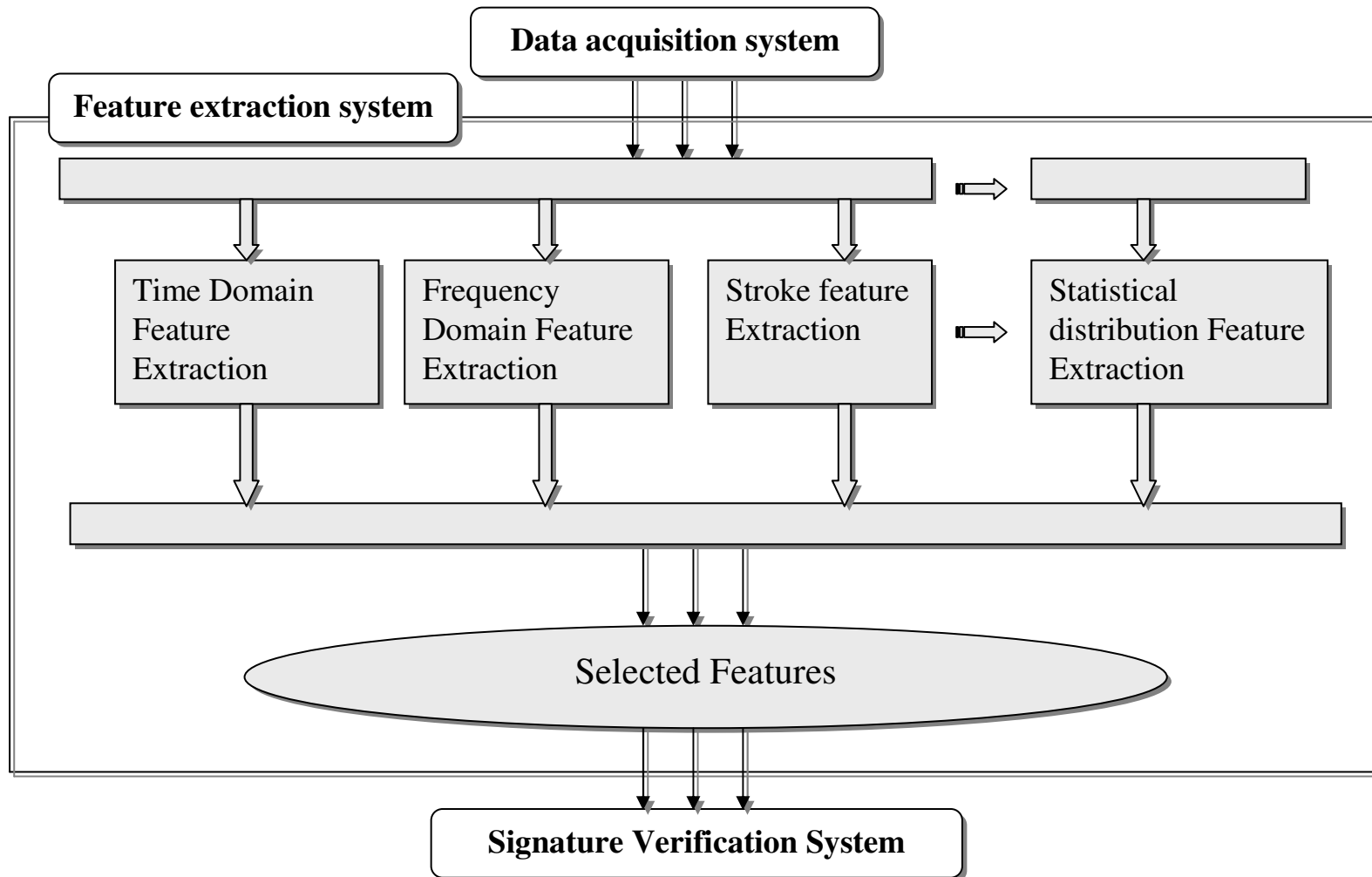- C++

➢ Analysis
- Matlab



*Patriot digital pad*

*A sample signature*

Pressure

Displacement x

Velocity x

Acceleration x

Displacement y

Velocity y

Acceleration y

Absolute Velocity

Angle

*Sampling time*
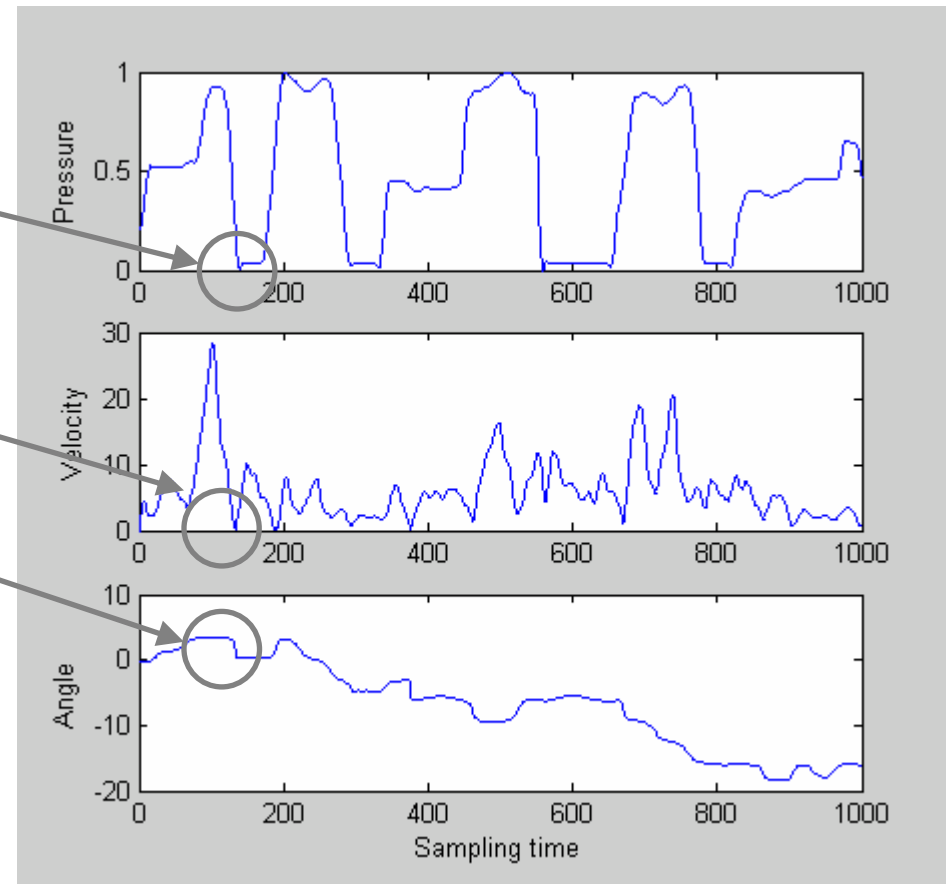
# 3. Feature Extraction Methods

# Stoke based Feature Extraction

## 1. Identify stroke boundaries

- **pen tip pressure ≈ 0**

- **pen velocity ≈0**

- **rapid change in pen angle**
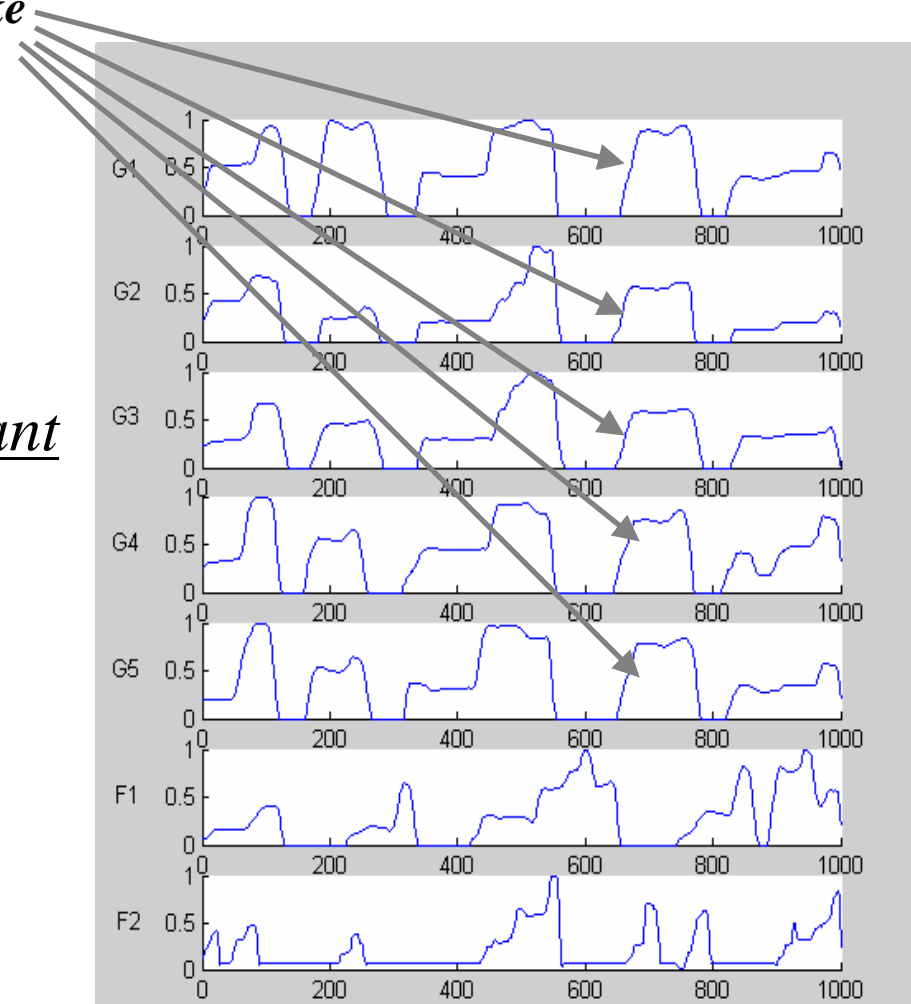
# Stoke based Feature Extraction

**Significant stroke**

## 2. Find significant stroke
- **Correspondence matching**
- **Maximum correlation values w.r.t reference signatures**

## 3. Extract features from significant stroke
- **Correlation values**
- **Stroke duration**
- **Stroke length**
- **Statistical distribution of stroke segmentation**
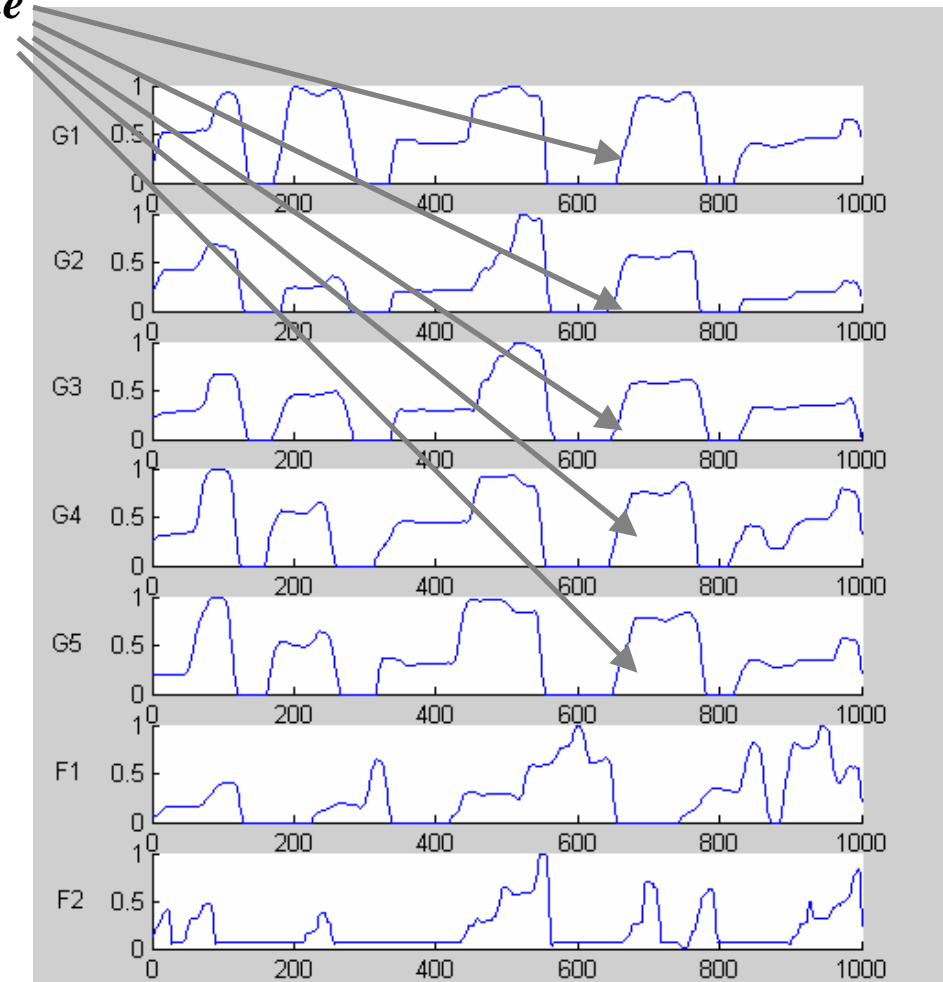
*Stroke-based normalized pressure vs. time*

# Stoke based Feature Extraction

**4th stroke's correlation between the signatures**

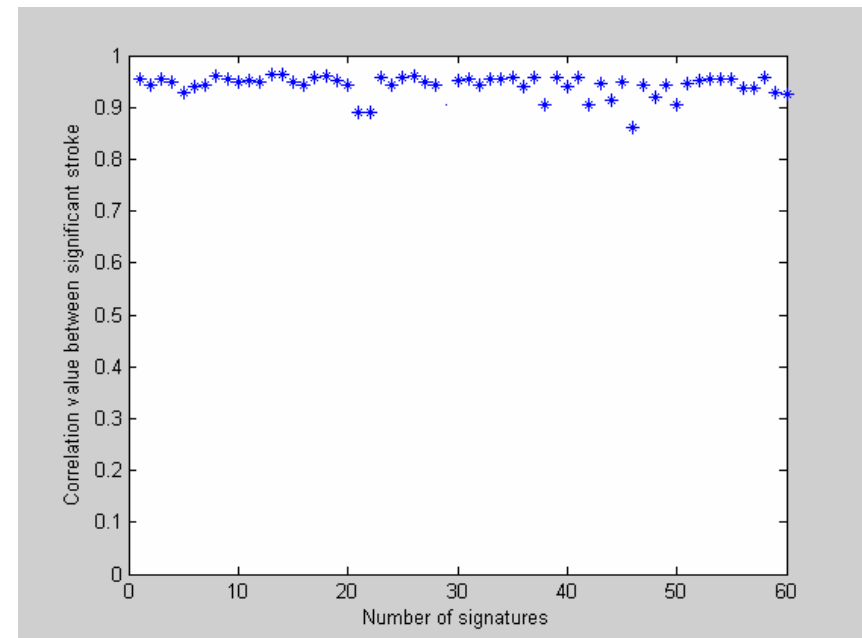|  | G1 | G2 | G3 |
|---|---|---|---|
| G1 | 1 | 0.9199 | 0.9830 |
| G2 | 0.9199 | 1 | 0.9595 |
| G3 | 0.9830 | 0.9595 | 1 |
| G4 | 0.9575 | 0.9678 | 0.9612 |
| G5 | 0.9846 | 0.9643 | 0.9834 |
| F1 | 0.5561 | 0.6729 | 0.5573 |
| F2 | 0.1508 | 0.1454 | 0.0815 |

*Stroke-based normalized pressure vs. time*

# *4. Feature distribution for signature classifier*
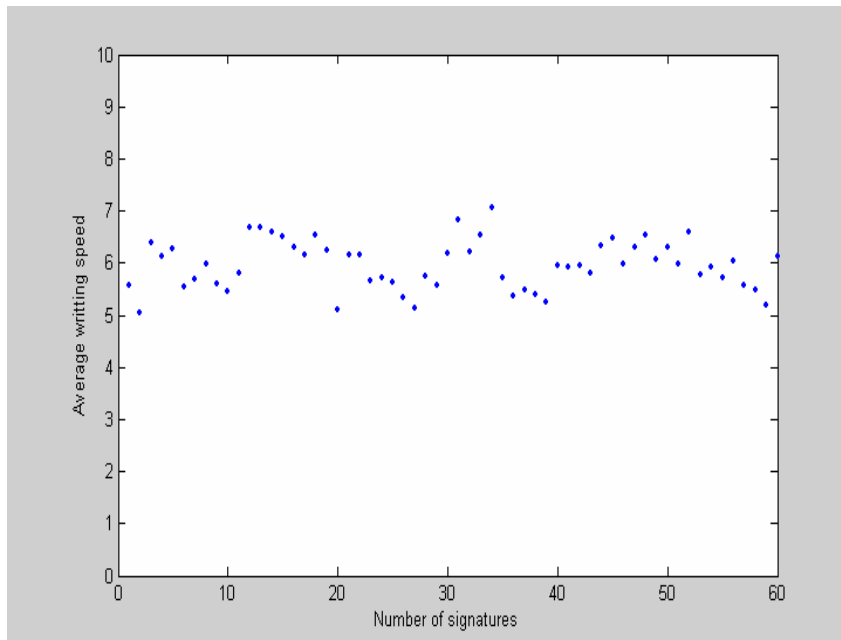


*Average writing speed  **vs.** number of signatures*



*Correlation value of significant stroke
**vs.**  number of signatures*

# *4. Feature distribution for signature classifier*

standard deviation | mean | standard deviation

Adjustable Threshold

Maximum Allowable Variation
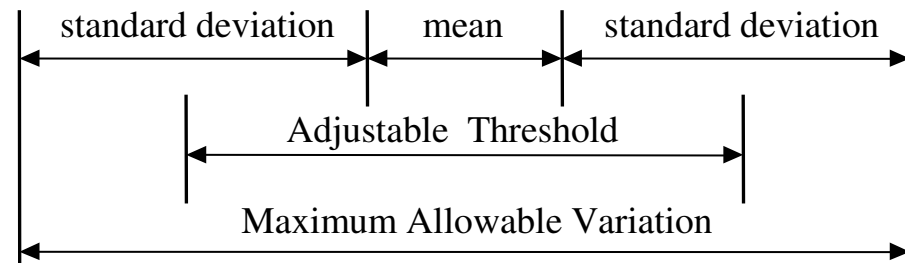
*Diagram of threshold adjustment*

Probability
Distribution

EER

Genuine

Forgery

Score
( e.g. a feature value)

0

false accept

false reject
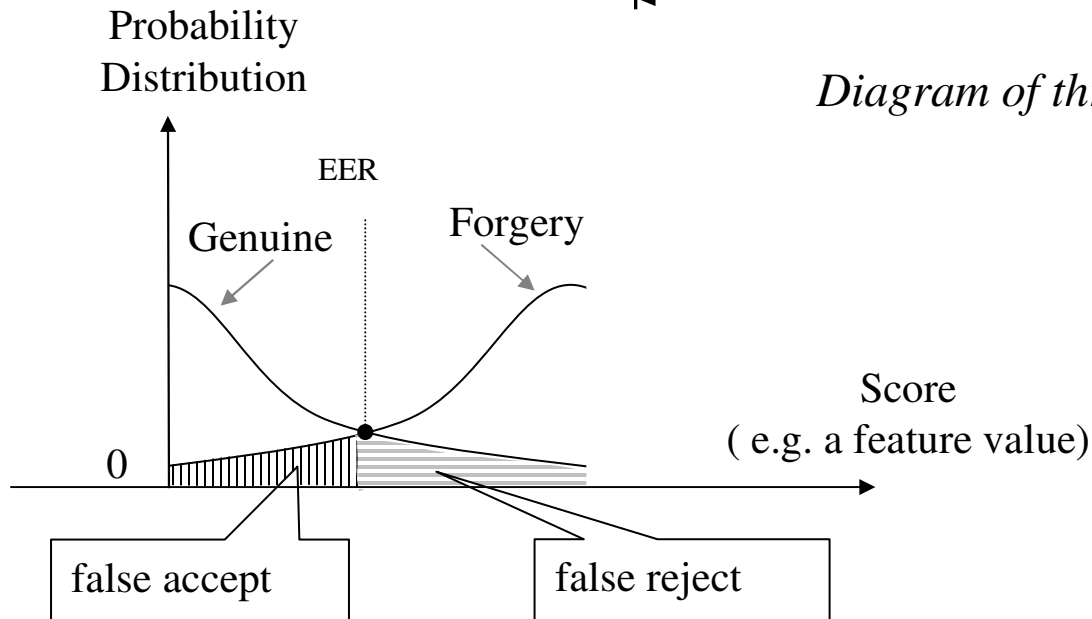
*Gaussian distribution for a person's genuine signature and forgeries*

## Experiment of setup

- # of volunteers : 10
- # of signatures:   240
- Training set :  130 signatures  (5, 10, 60 signatures respectively)
- Test set:  110 signature

## 6 features based verification

- Correlation value of the significant stroke in pressure signal
- The duration of the significant strokes
- Average writing speed
- Total time during the signing process
- Variance of pressure signal in 10 sliding windows
- Mean of the $x$ displacement signal in 100 sliding windows

## An example of experiment

| References | False Rejected | | | False Accepted | | |
|---|---|---|---|---|---|---|
| | Test Genuine | Assigned values to Features | Judgments | Forgery | Assigned values to Features | Judgments |
| Training1 Training2 Training3 Training4 Training5 | G1 | 0  0  0  0  0  0 | Accept | F1 | 1  1  1  1  0  0 | Reject |
| | G2 | 0  0  0  0  0  1 | Accept | F2 | 0  1  0  0  0  1 | Reject |
| | G3 | 0  0  1  0  0  0 | Accept | F3 | 1  0  1  1  0  0 | Reject |
| | G4 | 0  0  0  0  0  0 | Accept | F4 | 1  1  0  0  0  1 | Reject |
| | G5 | 0  0  0  1  0  0 | Accept | F5 | 1  0  1  1  1  0 | Reject |
| | G6 | 0  1  0  0  1  0 | **False reject** | F6 | 1  1  1  1  0  0 | Reject |
| **Note** | Threshold 80% | | | | | |

- 4 out of 60 genuine signatures were rejected , FRR of 6.67%
- 1 out of 50 forgery signatures were accepted , FAR of 1.67%

## Conclusions

- A novel stroke based feature algorithm was developed
- A DSV system was successfully designed, developed, and tested
- Compact system developed by Matlab and WINTab API
- FRR of 6.67%
- FAR of 1.67%

## Future work

- Variable threshold will be used , and calculation of the FAR and FRR data for the detection error tradeoff curve
- More features will be evaluated and implemented
- Application to Virtual Environments:
  - To authenticate collaborative participants