Incorporating Touch Biometrics to Mobile One-Time Passwords: Exploration of Digits

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BiDA Lab

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Outline

1. Introduction
2. e-BioDigit Database
3. Handwritten Touch Biometric System
4. Experimental Work
5. Conclusions and future Work

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Introduction

Introduction

- Mobile devices have become an indispensable tool for most people nowadays

Social Networks

On-Line Payments

Introduction

- Public and Private Sectors are aware of the importance of mobile devices in our society
- Deployment of their services through security and user-friendly mobile applications

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- Public and Private Sectors are aware of the importance of mobile devices in our society
- Deployment of their services through security and user-friendly mobile applications

- However, difficult to accomplish using only traditional approaches

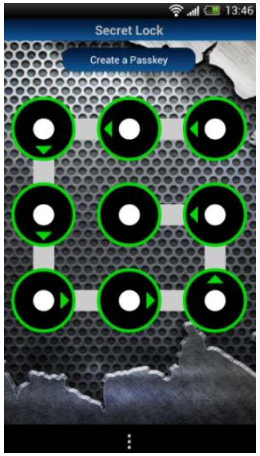
Personal Identification Number (PIN)

One-Time Password (OTP)

Introduction

- Biometric recognition schemes can cope with these problems as they combine:

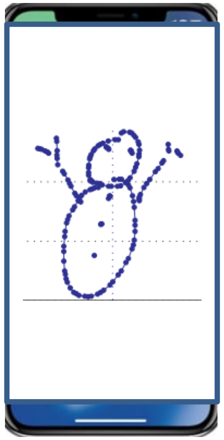
- Behavioural biometric systems very attractive on mobile scenarios



Dynamic Lock Patterns

Touch Biometrics

Handwritten Signature



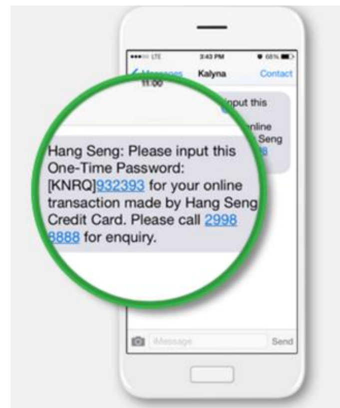
Graphical Passwords

Proposed Approach

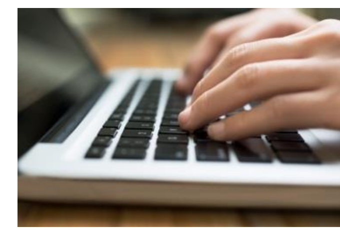
- Incorporate touch biometrics to mobile one-time passwords (OTP):

On-Line Payments

User Mobile Message



Authentication



Proposed Approach

- Incorporate touch biometrics to mobile one-time passwords (OTP):

On-Line Payments

OTP System
(e.g. 934)

Advantages:
- Users do not memorize passwords
- User-friendly interface (mobile scenarios)
- Security level easily configurable
  - # enrolment samples
  - Length password

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e-BioDigit Database

e-BioDigit Database*

Users: 93

Session 1 → (3 weeks) → Session 2

Session 1

10 numerical digits (0,1,..,9)
4 samples/numerical digit

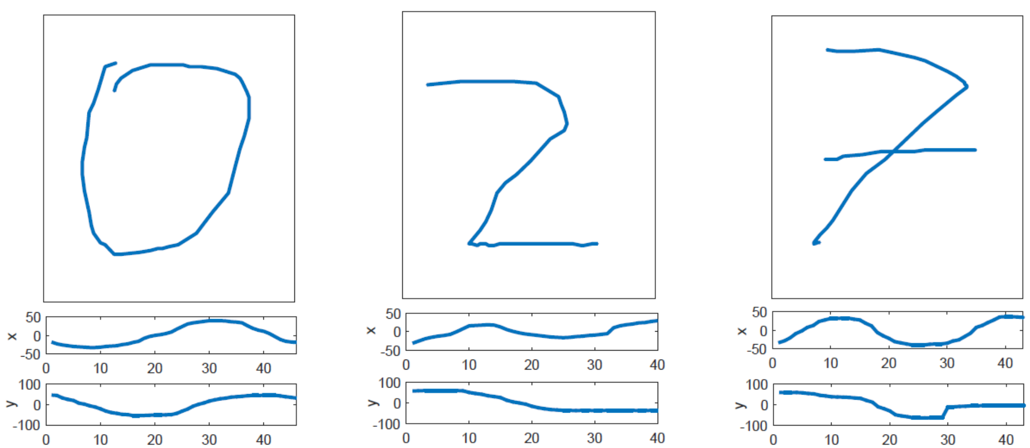
Session 2

10 numerical digits (0,1,..,9)
4 samples/numerical digit

Mobile Device: 

Input: 

- Acquisition: one handwritten digit at a time. Only *X* and *Y* time information



*Available at: https://atvs.ii.uam.es/atvs/e-BioDigit.html

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Handwritten Touch Biometric System

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Touch Biometric System

- Feature Extraction and Selection:

#	Feature
1	X-coordinate: x_n
2	Y-coordinate: y_n
3	Path-tangent angle: θ_n
4	Path velocity magnitude: v_n
5	Log curvature radius: ρ_n
6	Total acceleration magnitude: a_n
7-12	First-order derivative of features 1-7: $\dot{x_n}, \dot{y_n}, \dot{\theta_n}, \dot{v_n}, \dot{\rho_n}, \dot{a_n}$
13-14	Second-order derivative of features 1-2: $\ddot{x_n}, \ddot{y_n}$
15	Ratio of the minimum over the maximum speed over a 5-samples window: v_n^r
16-17	Angle of consecutive samples and first-order derivative: α_n, $\dot{\alpha_n}$
18	Sine: s_n
19	Cosine: c_n
20	Stroke length to width ratio over a 5-samples window: r_n^5
21	Stroke length to width ratio over a 7-samples window: r_n^7

- 21 time functions for each handwritten digit
- Selection of best time functions for each digit
  - Sequential Forward Feature Selection Algorithm (SFFS)

Touch Biometric System

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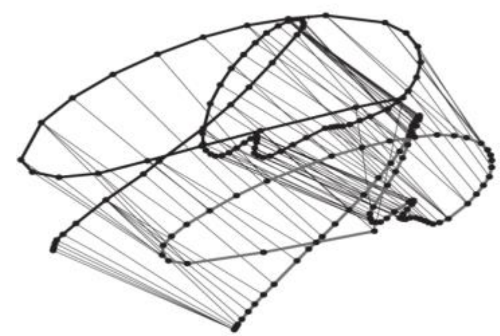
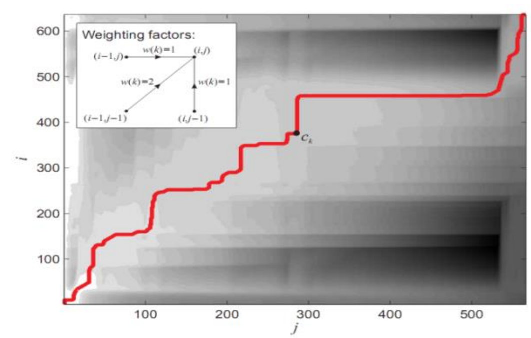
Matcher:

Dynamic Time Warping (DTW)





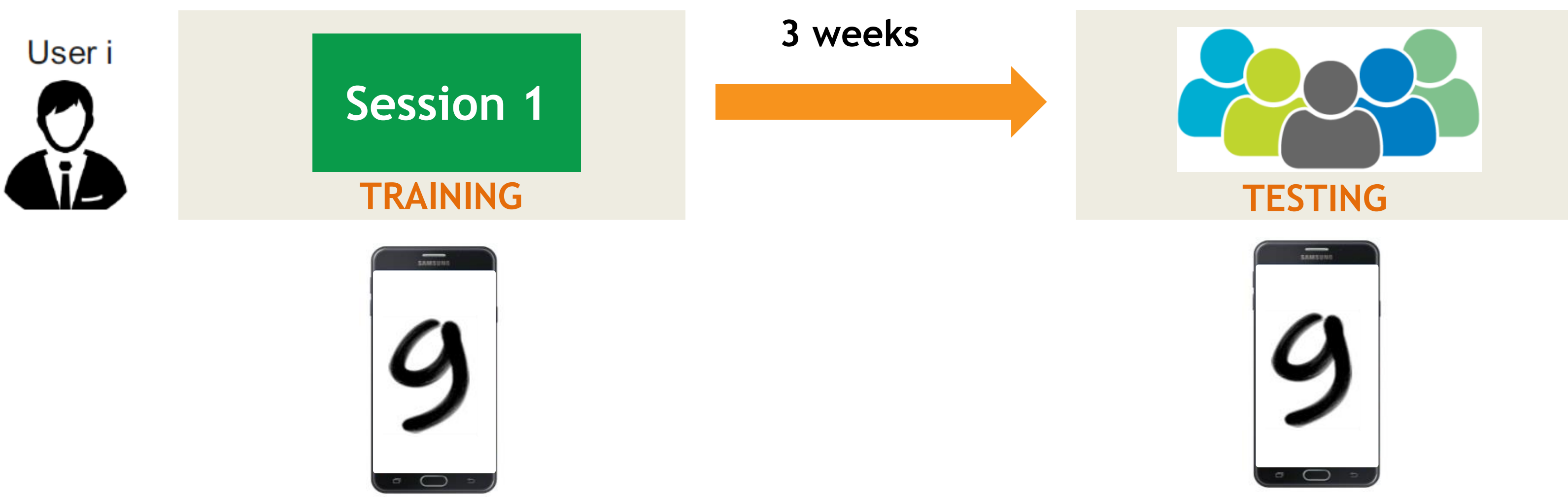
4 Experimental Work

Experimental Protocol

- Development: 50 users of e-BioDigit database
- Evaluation: remaining 43 users of e-BioDigit database

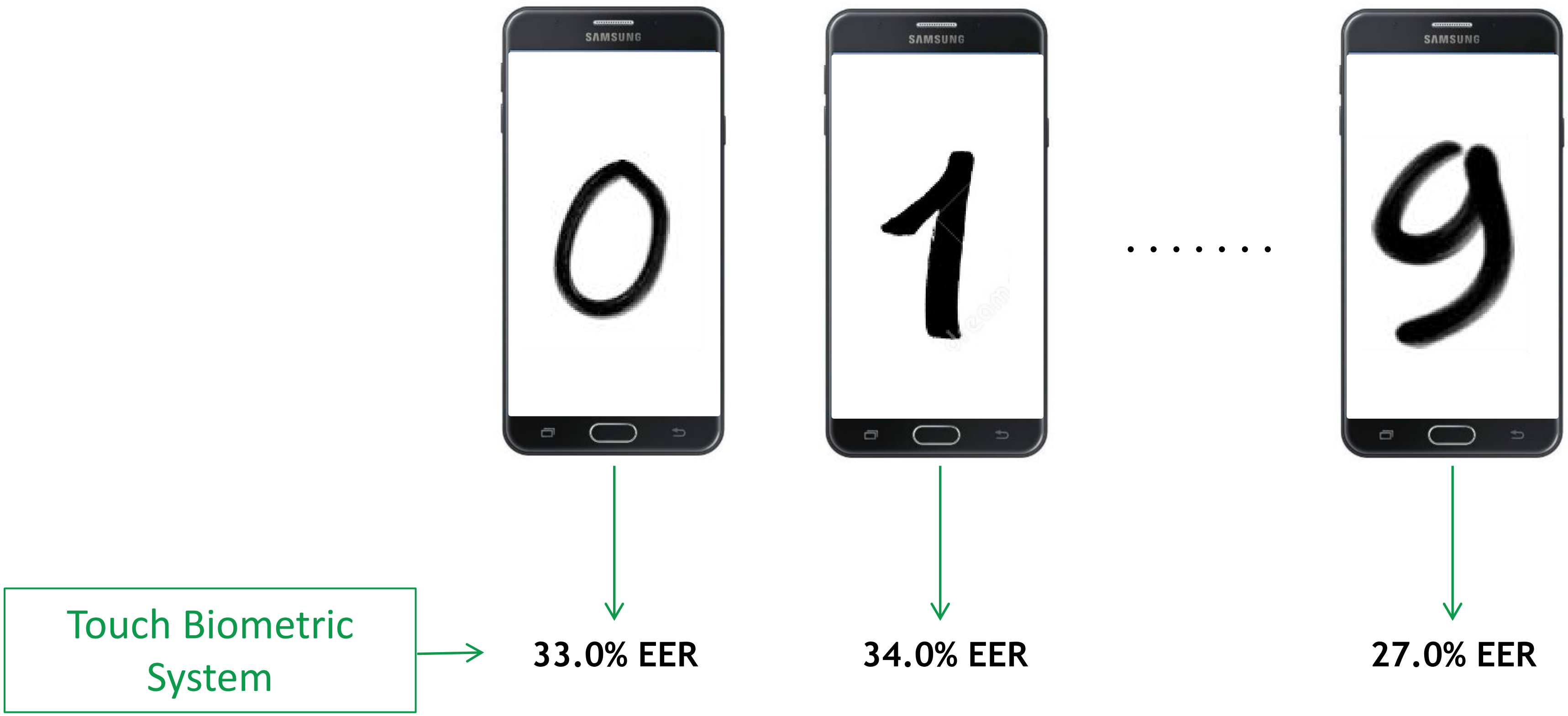
- Genuine Scores

- Impostor Scores



Experiment 1: One-Digit Results

- Analysis of the potential of each numerical digit



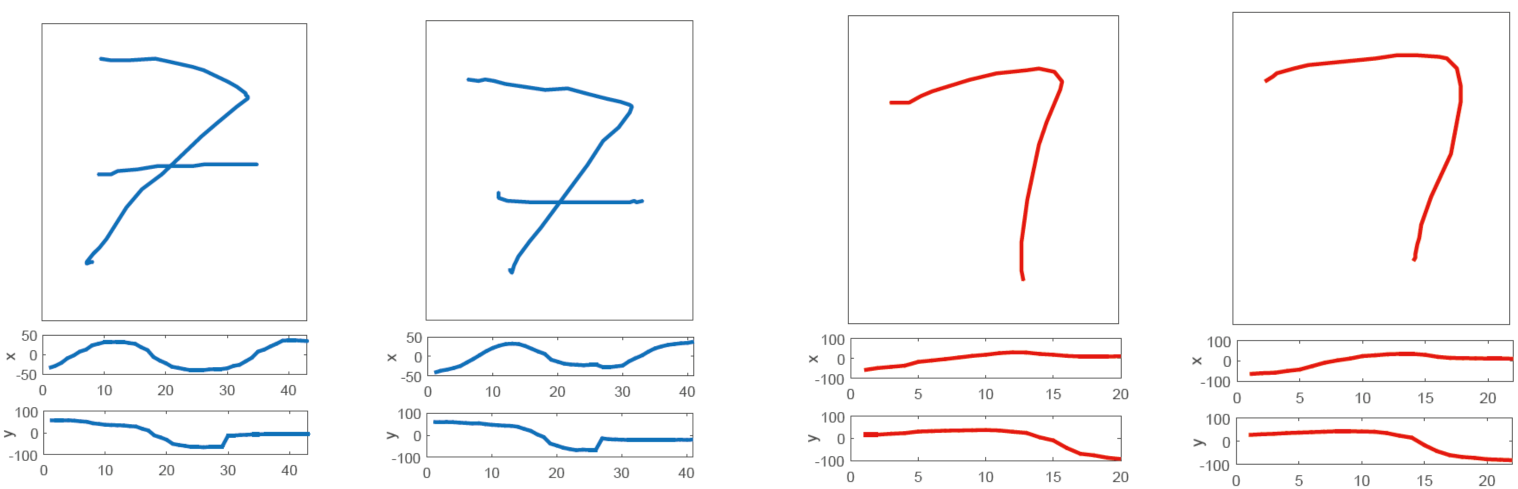
Experiment 1: One-Digit Results

- System performance results in terms of EER (%) on the evaluation dataset

	Handwritten Numerical Digit									
	0	1	2	3	4	5	6	7	8	9
EER (%)	33.0	34.0	30.9	32.3	22.0	**21.7**	33.6	**21.8**	21.8	27.0

 # enrolment samples per digit: 1

- High different system performance between numerical digits
- Digit 5 and 7 provide the best system performance results



User A: sample 1 **User A: sample 2** **User B: sample 1** **User B: sample 2**

Experiment 2: Digit Combination Results

- Analysis of the system performance regarding:
  - Length of handwritten password

	1 digit	2 digits		8 digits
Password	5	5 7	. . . .	5 7 3 7 9 5 5 2
Performance EER (%)	**21.7**	**?**		**?**

  - # enrolment samples per digit

	1 sample	2 samples		4 samples
# Enrolment Samples/Digit	5	5 5	. . . .	5 5 5 5
Performance EER (%)	**21.7**	**?**		**?**

Experiment 2: Digit Combination Results

- System performance results in terms of EER (%) on the evaluation dataset

# enrolment samples per digit	# Digits that comprise the password							
	1	2	3	4	5	6	7	8
1	21.7	14.0	11.6	11.6	9.3	8.5	8.5	8.5
2								
3								
4								

- Improvement of system performance when adding more digits to the password
  - e.g. absolute improvement of 7.7% EER between 1- and 2-digit passwords

Experiment 2: Digit Combination Results

- System performance results in terms of EER (%) on the evaluation dataset

# enrolment samples per digit	# Digits that comprise the password							
	1	2	3	4	5	6	7	8
1	21.7							
2	18.6							
3	16.3							
4	16.9							

- Improvement of System performance when adding more enrolment samples
  - e.g. absolute improvement of 4.8% EER between 1 and 4 enrolment samples

Experiment 2: Digit Combination Results

- System performance results in terms of EER (%) on the evaluation dataset

# enrolment samples per digit	# Digits that comprise the password: 1	2	3	4	5	6	7	8
1	21.7	14.0	11.6	11.6	9.3	8.5	8.5	8.5
2	18.6	11.6	9.3	7.4	7.3	4.6	4.6	4.6
3	16.3	9.5	7.4	5.9	4.7	4.6	**3.8**	4.6
4	16.9	11.6	7.0	6.1	4.7	4.6	4.3	4.8

- However, there is a limit in the system performance improvement with:
  - Length of the password (6/7 digits)
  - # enrolment samples per digit (3)

Comparison to State-of-the-Art Systems

Work	Method	Verification Performance (EER)		Participants
		Random Forgeries	Skilled Forgeries	
Angulo and Wastlund (2011)	Lock Pattern Dynamics	-	10.39% avg.	32
Sae *et al.* (2014)	Touchscreen Gestures	1.58%	-	34
Pozo *et al.* (2017)	Touchscreen Gestures	15.0%	-	190
Li *et al.* (2013)	Touchscreen Gestures	3.0%	-	75
Shen *et al.* (2016)	Touchscreen Gestures	$\sim$3.0%	-	71
Martinez-Diaz *et al.* (2016)	Graphical Passwords	3.4%	22.1%	100
Sae and Memon (2014)	Handwritten Signatures	5.04%	-	180
Tolosana *et al.* (2017)	Handwritten Signatures	0.5%	17.9%	65
Kutzner *et al.* (2015)	Handwritten Characters	-	FAR = 10.42% FRR = unknown	32
Proposed Approach	**Handwritten Digits**	**-**	**3.8%**	**93**

- Proposed approach outperforms other touch biometric approaches for skilled forgeries
  - User-friendly interface ☺
  - Small number of enrolment samples ☺

5 Conclusions and Future Work

Conclusions

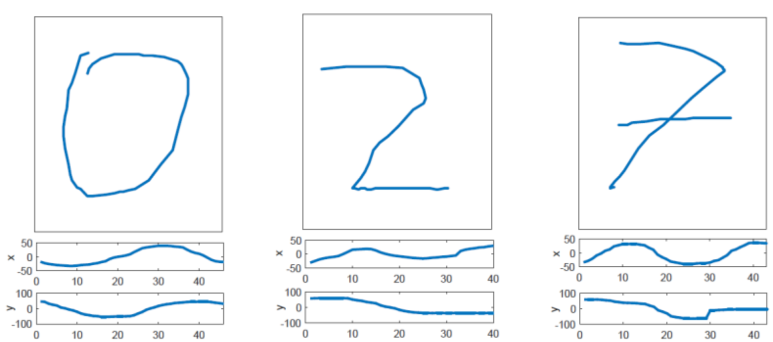
- We incorporate touch biometrics to password-based mobile authentication systems

OTP System
(e.g. 934)

Touch Biometric System

- Perform a complete analysis regarding:
  - Which are the most discriminative handwritten digits
  - How performance improves with # enrolment samples per digit and length of the password

- e-BioDigit database is publicly available to the research community



Available at: https://atvs.ii.uam.es/atvs/e-BioDigit.html

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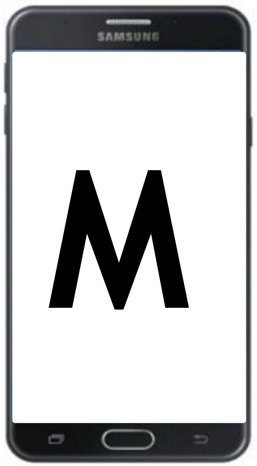
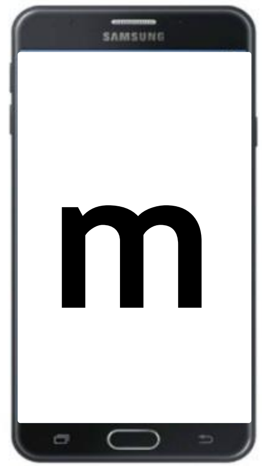
Future Work

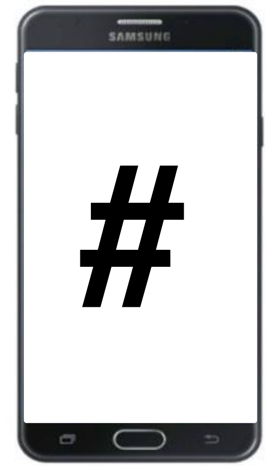
- We will extend this approach to:



Capital Letters



Small Letters



Symbols

- We will improve the core matcher through Deep Learning techniques

* R. Tolosana, R. Vera-Rodriguez, Julian Fierrez and Javier Ortega-Garcia, “Exploring Recurrent Neural Networks for On-Line Handwritten Signature Biometrics", IEEE Access, pp. 1 - 11, 2018

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