ANTI-SPOOFING EVALUATION OF DYNAMIC HANDWRITTEN SIGNATURE ALGORITHMS

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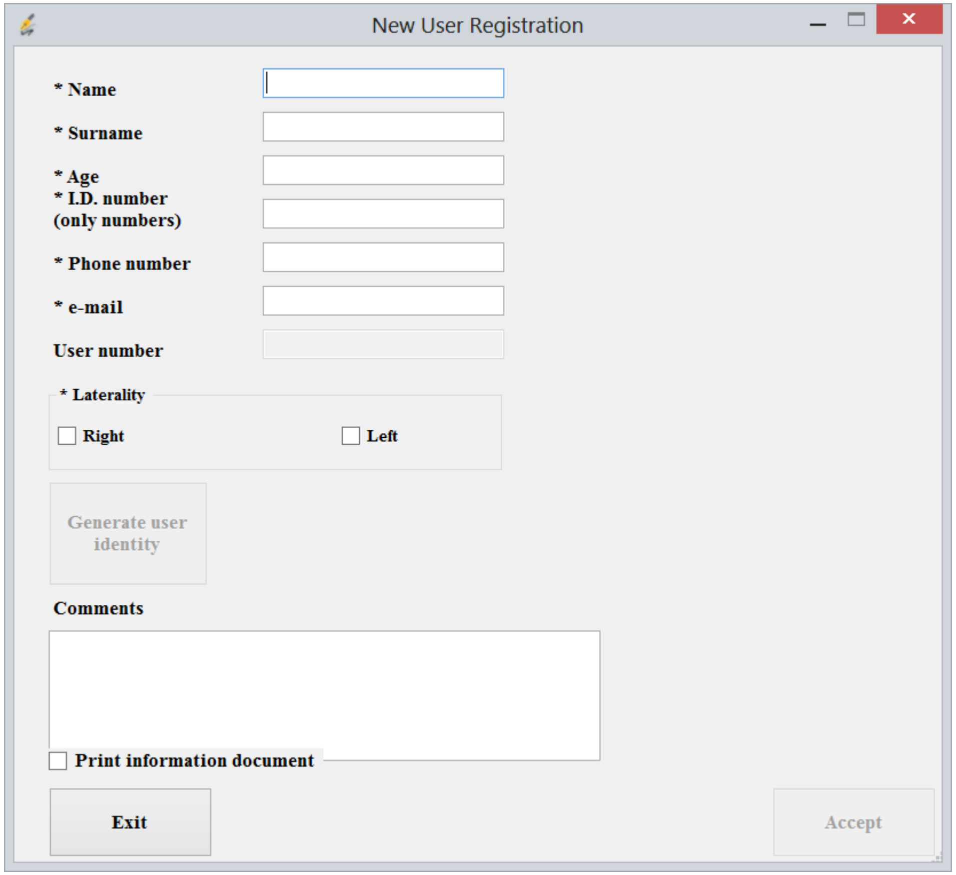
HANDWRITTEN SIGNATURE TOOLBOX

- Genuine and Forgeries Acquisition Process
- 7 Levels of Knowledge when forging
  - Knowledge acquired controlled by the toolbox
- ISO/IEC 19794-7 2nd Generation for storing the samples acquired
- Files stored by:
  - Category (genuine/forgery)
  - User ID
  - Sample number
  - For forgeries, sample level
- Samples stored as individual files
- Availability expected by Q2-Q3 2013

- Requirements:
  - Microsoft Windows
  - Wacom STU-500 Tablet

GENUINE AND FORGER REGISTRATION

- Collects contacting information
- Allows Genuine, Forger or Both
- Personal data non attached to sample files



New User Registration

* Name

* Surname

* Age

* I.D. number (only numbers)

* Phone number

* e-mail

User number

* Laterality

□ Right □ Left

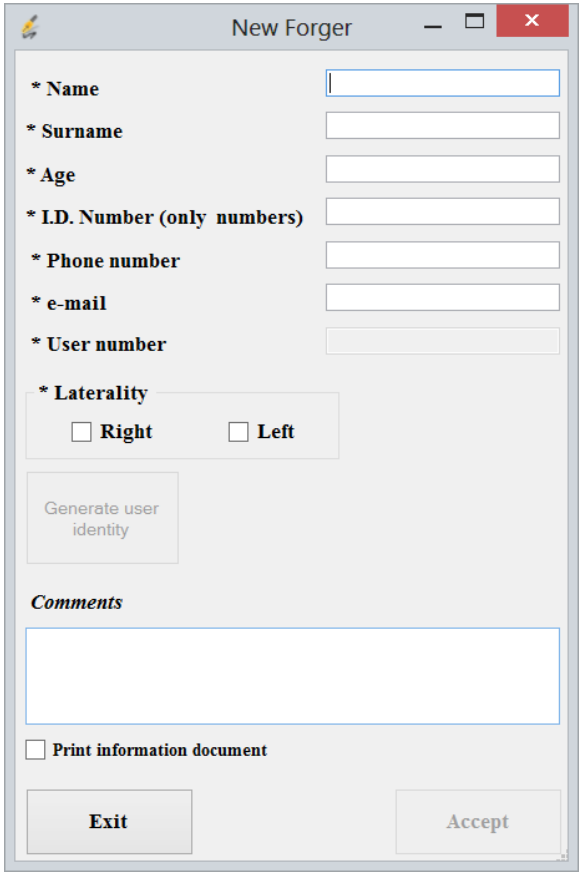
Generate user identity

Comments

□ Print information document

Exit

Accept



New Forger

* Name

* Surname

* Age

* I.D. Number (only numbers)

* Phone number

* e-mail

* User number

* Laterality

□ Right □ Left

Generate user identity

Comments

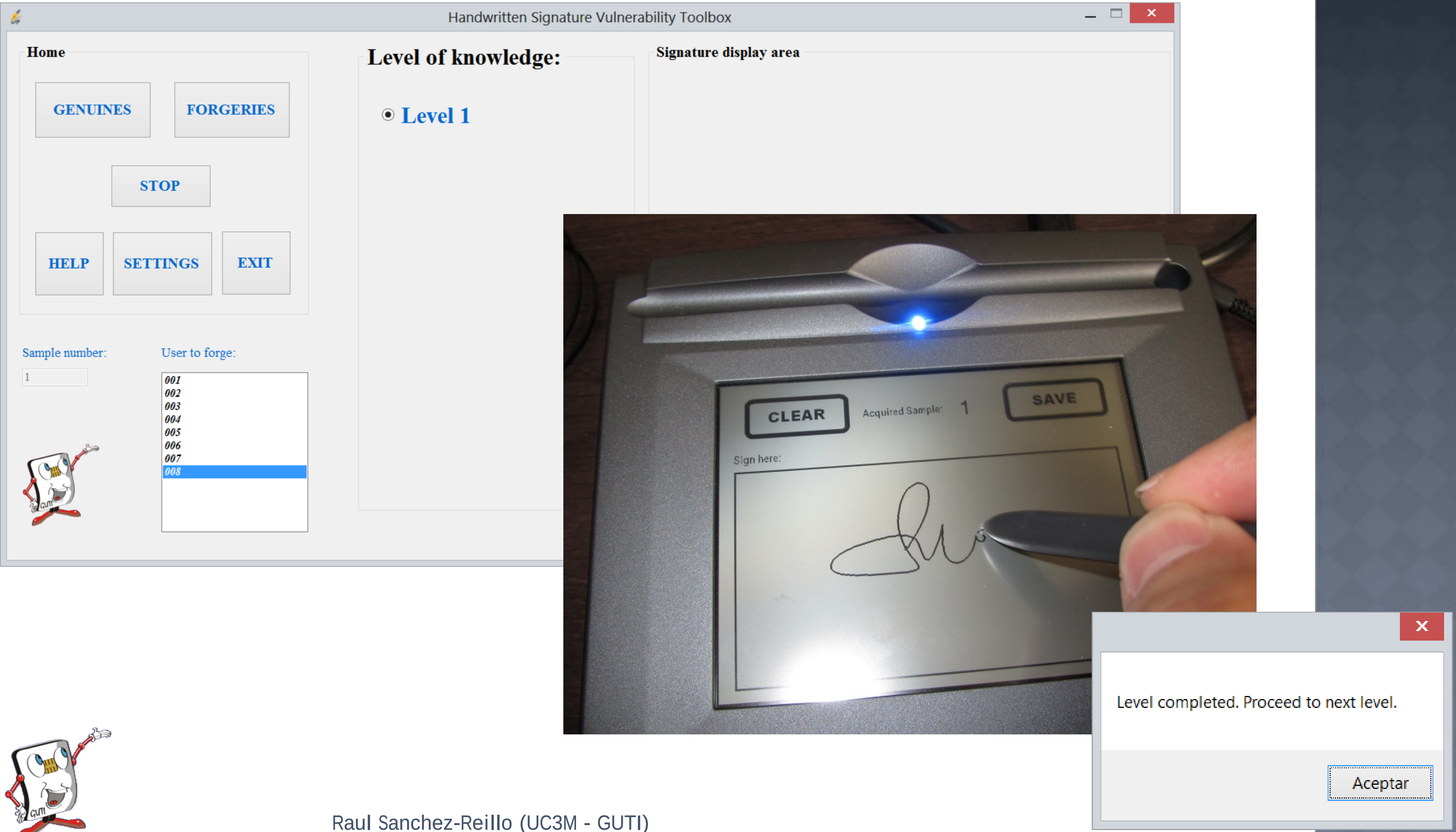
□ Print information document

Exit

Accept

FORGERIES: LEVEL 1

- No a-priory knowledge about the signature



Handwritten Signature Vulnerability Toolbox

Home

GENUINES FORGERIES

STOP

HELP SETTINGS EXIT

Sample number: 1

User to forge:

001
002
003
004
005
006
007
008

Level of knowledge:

● Level 1

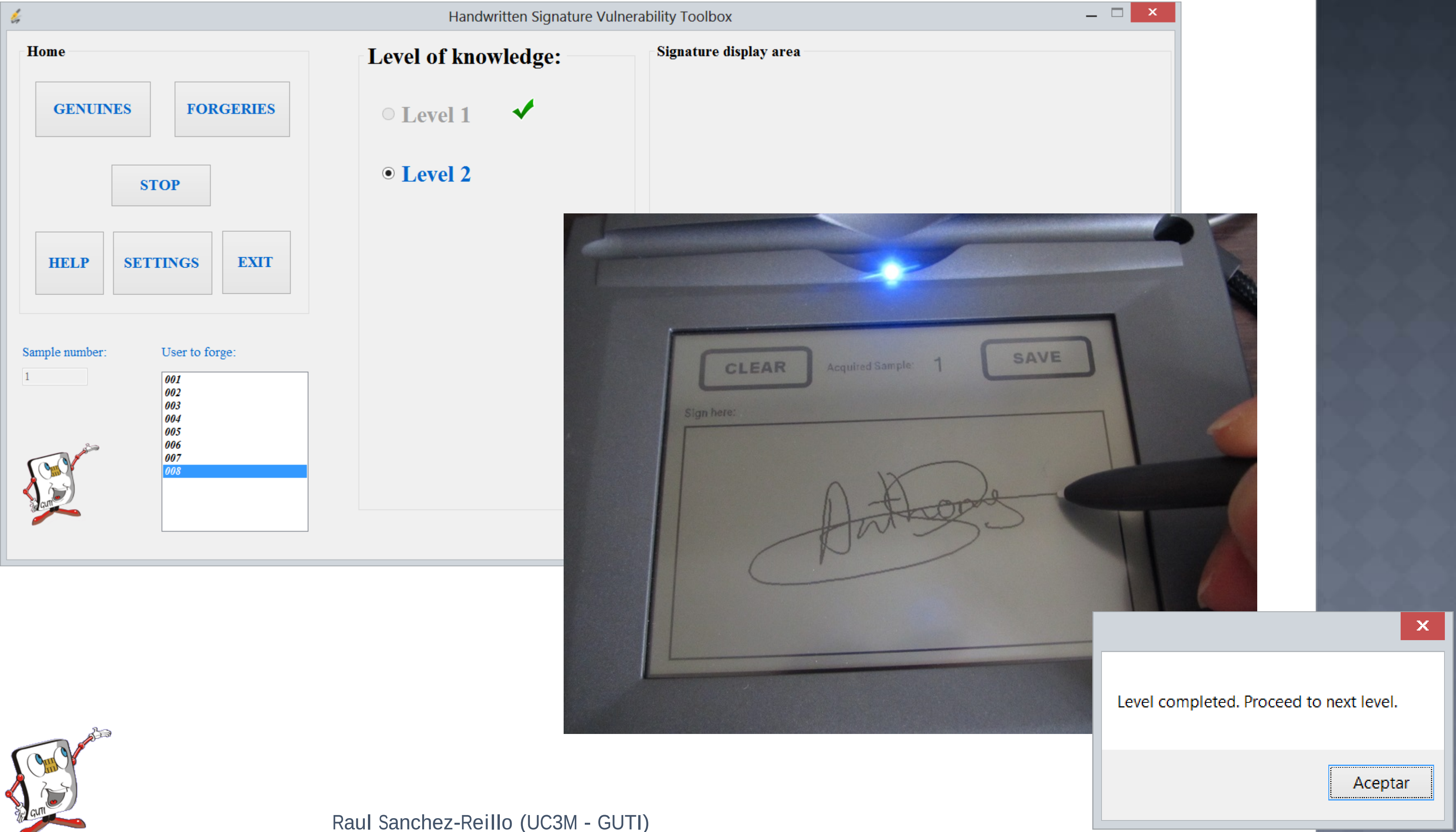
Signature display area

Level completed. Proceed to next level.

Aceptar

FORGERIES: LEVEL 2

- Temporal knowledge about static signature (5s)



Level of knowledge:

○ Level 1 ✓

● Level 2

Sample number: 1

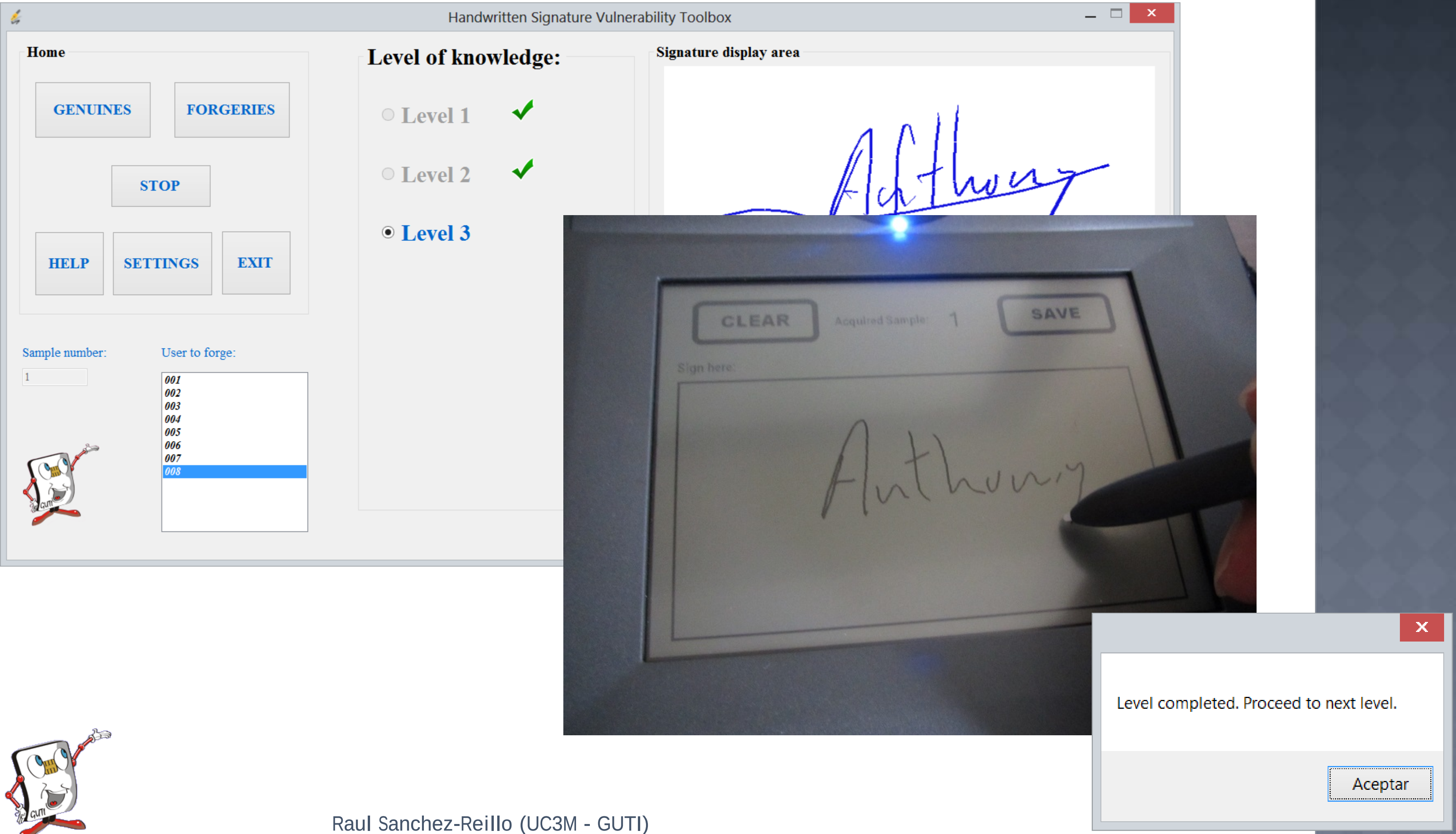
User to forge: 001, 002, 003, 004, 005, 006, 007, 008 (008 selected)

Acquired Sample: 1

Level completed. Proceed to next level.

FORGERIES: LEVEL 3

- Permanent knowledge about static signature



Handwritten Signature Vulnerability Toolbox

Level of knowledge:

○ Level 1 ✓

○ Level 2 ✓

● Level 3

Signature display area

Sample number: 1

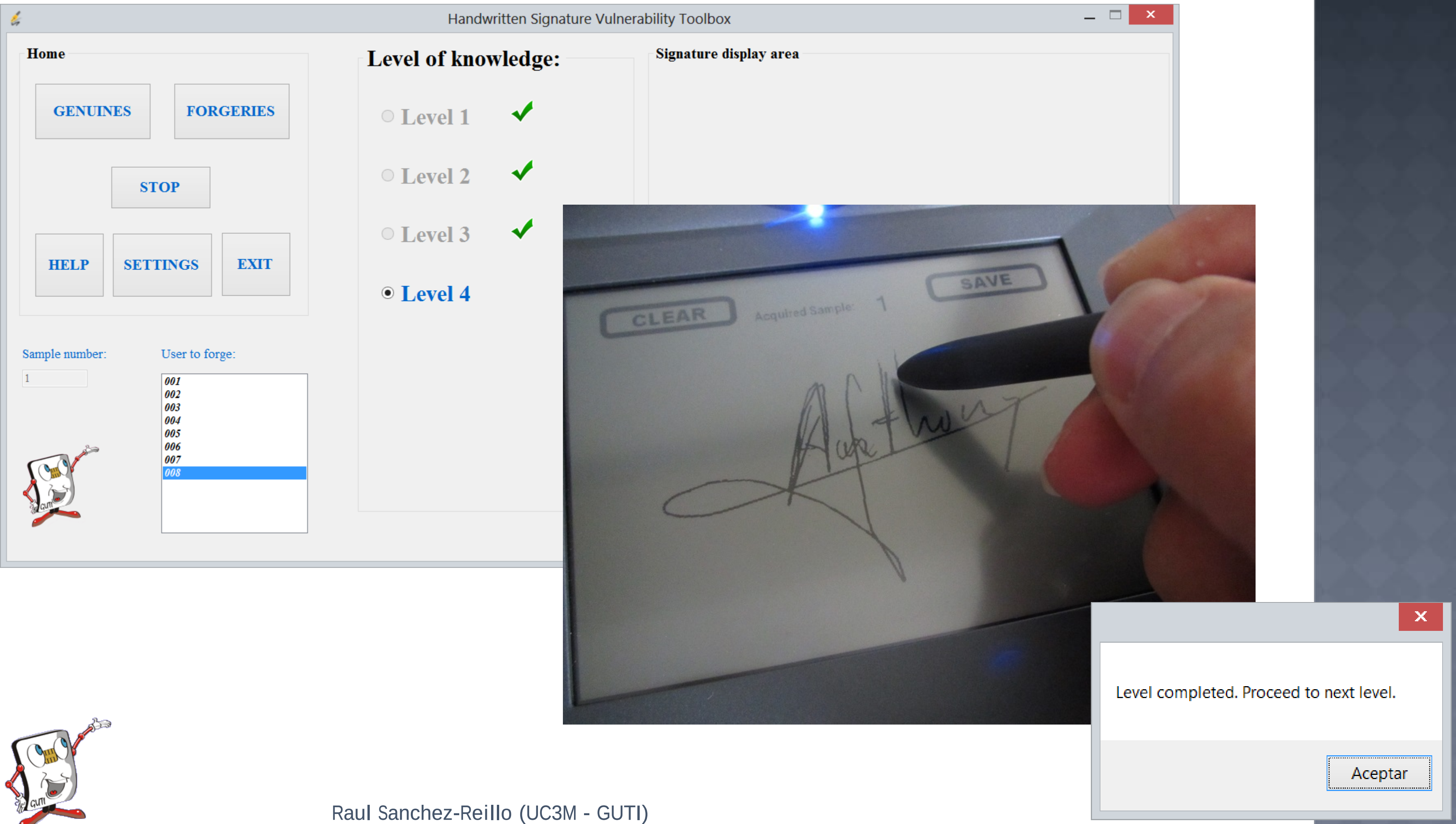
User to forge:

001
002
003
004
005
006
007
008

Level completed. Proceed to next level.

FORGERIES: LEVEL 4

- “Carbon-copy”



Handwritten Signature Vulnerability Toolbox

Sample number: 1

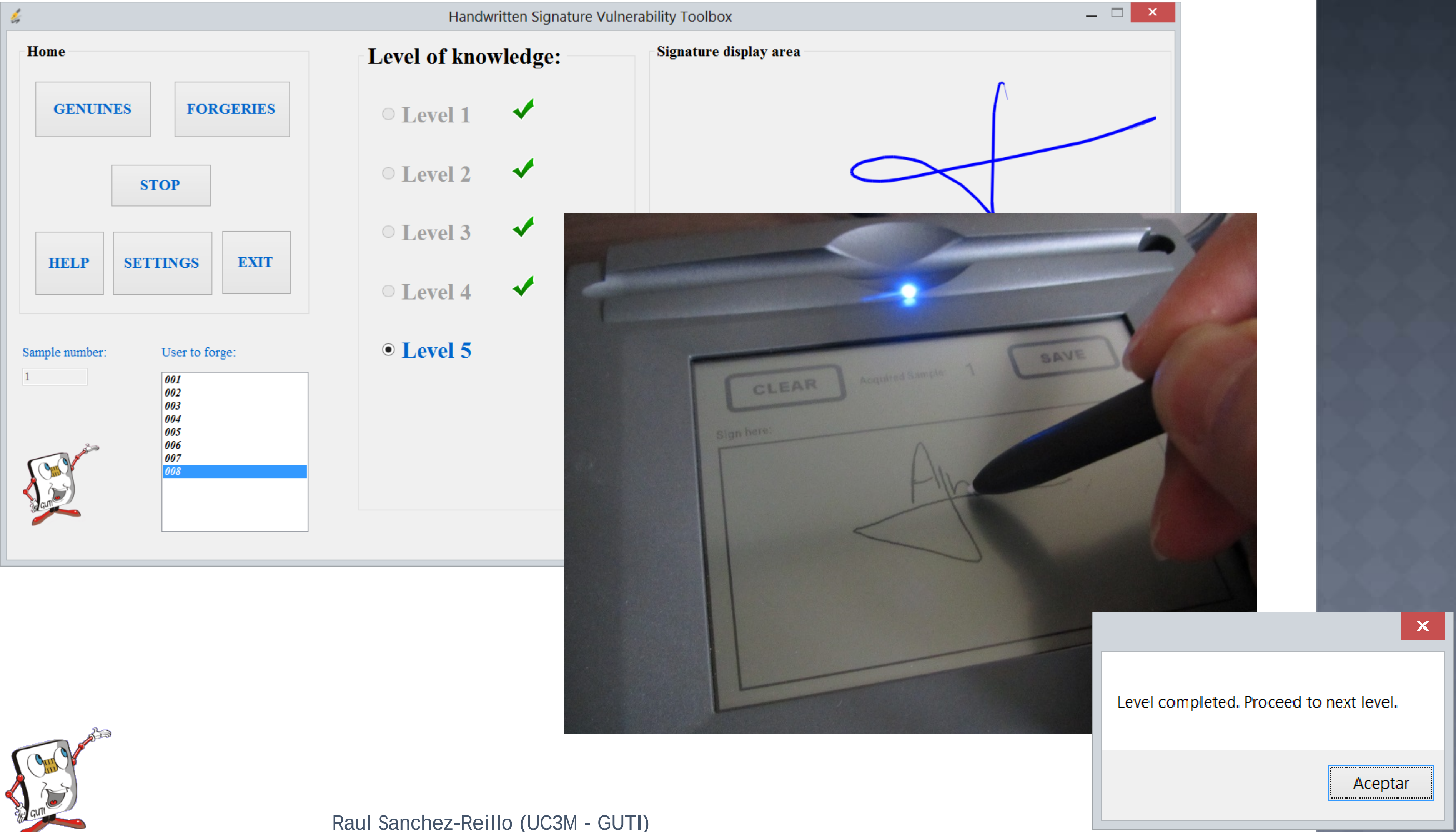
User to forge: 001, 002, 003, 004, 005, 006, 007, 008 (selected: 008)

Acquired Sample: 1

Level completed. Proceed to next level.

FORGERIES: LEVEL 5

- Temporal knowledge about dynamic signature (1 replay)



Handwritten Signature Vulnerability Toolbox

Home

GENUINES | FORGERIES

STOP

HELP | SETTINGS | EXIT

Sample number: 1

User to forge:
001
002
003
004
005
006
007
008

Level of knowledge:

○ Level 1 ✓
○ Level 2 ✓
○ Level 3 ✓
○ Level 4 ✓
● Level 5

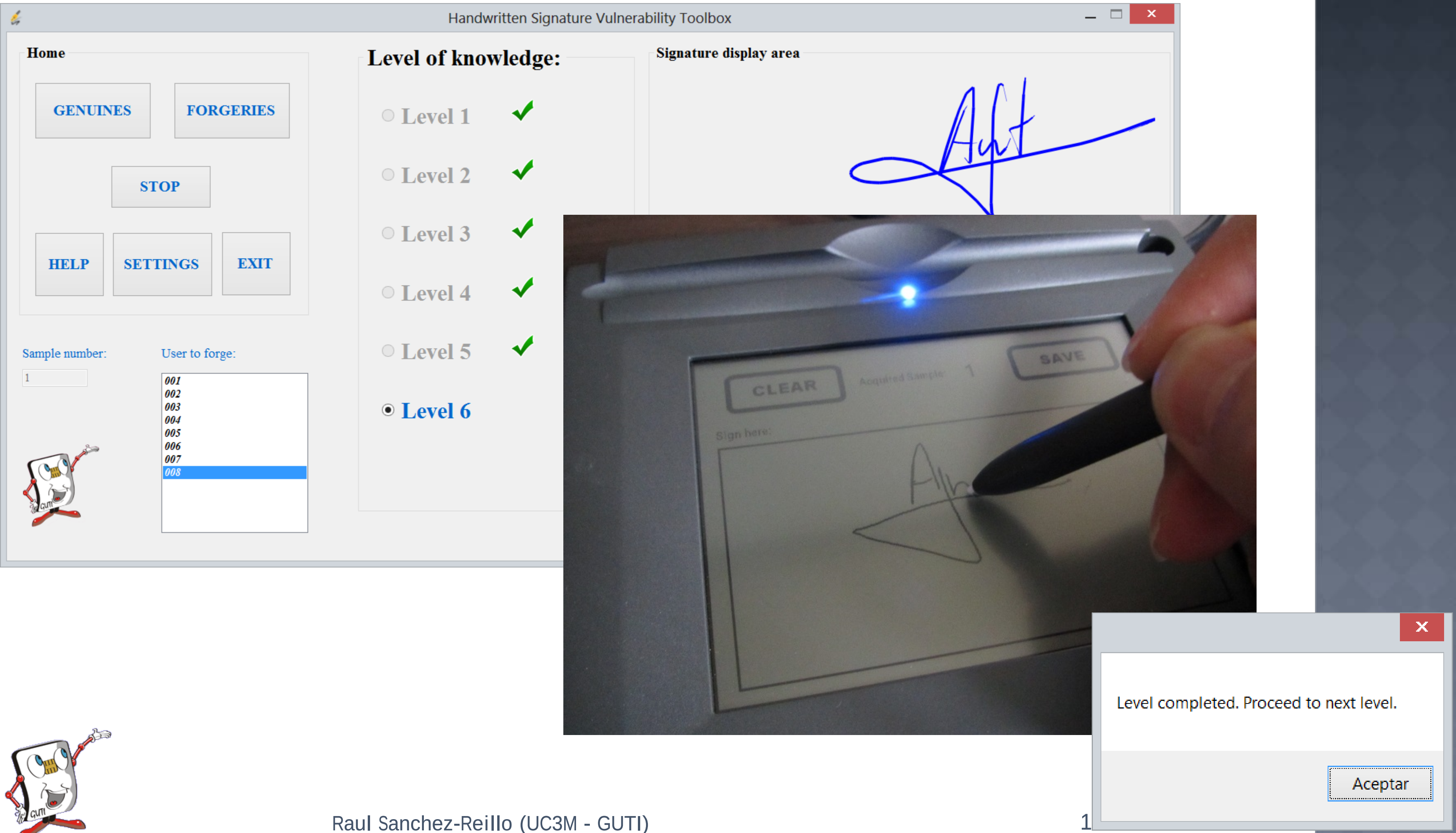
Signature display area

Level completed. Proceed to next level.

Aceptar

FORGERIES: LEVEL 6

- Controlled knowledge about the dynamic signature



Handwritten Signature Vulnerability Toolbox

Sample number: 1

User to forge:
001
002
003
004
005
006
007
008

Level of knowledge:

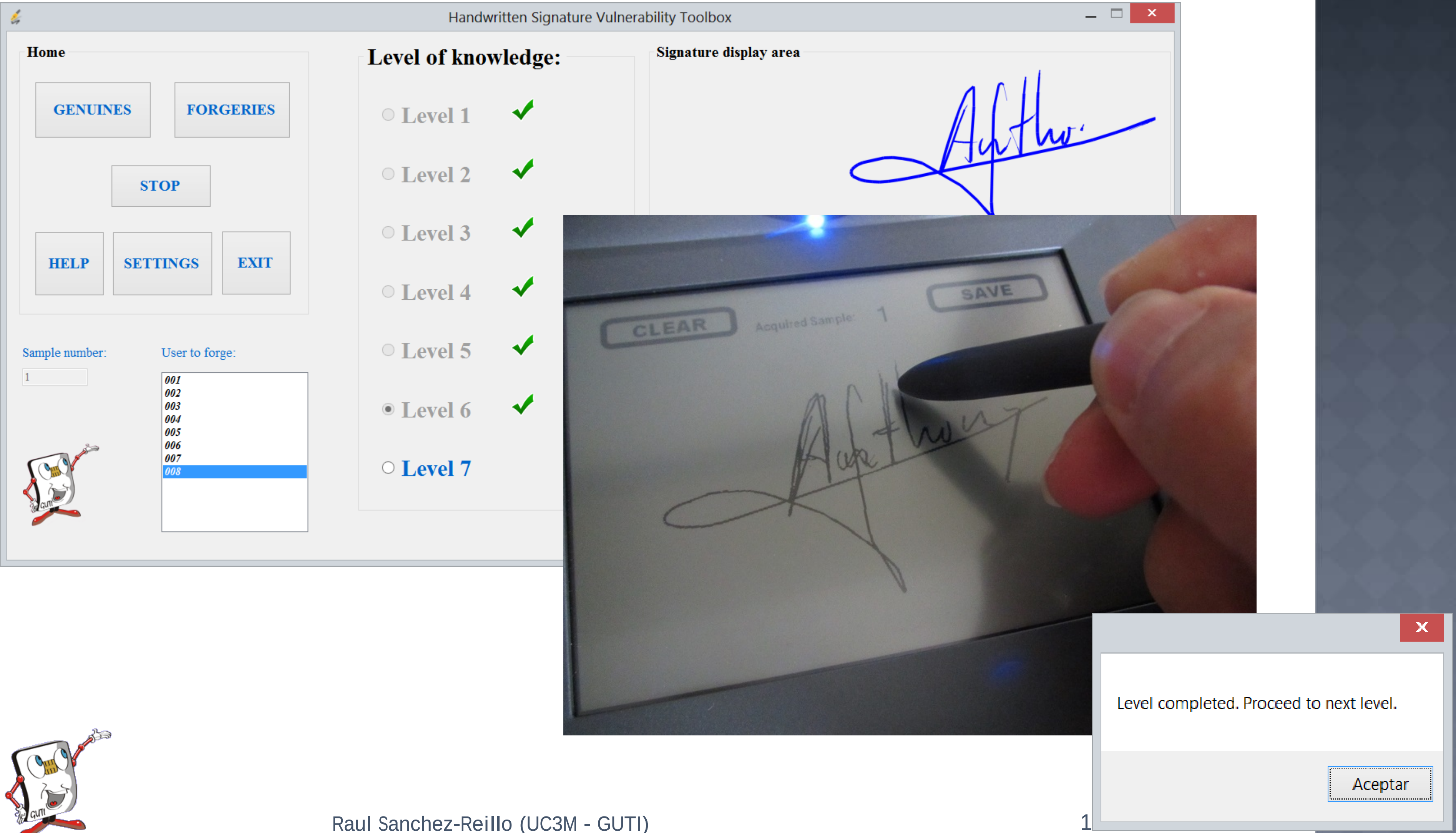
○ Level 1 ✓
○ Level 2 ✓
○ Level 3 ✓
○ Level 4 ✓
○ Level 5 ✓
● Level 6

Signature display area

Level completed. Proceed to next level.

FORGERIES: LEVEL 7

- Level 6 + Carbon-copy



Handwritten Signature Vulnerability Toolbox

Home

Sample number: 1

User to forge:

001
002
003
004
005
006
007
008

Level of knowledge:

○ Level 1 ✓
○ Level 2 ✓
○ Level 3 ✓
○ Level 4 ✓
○ Level 5 ✓
● Level 6 ✓
○ Level 7

Signature display area

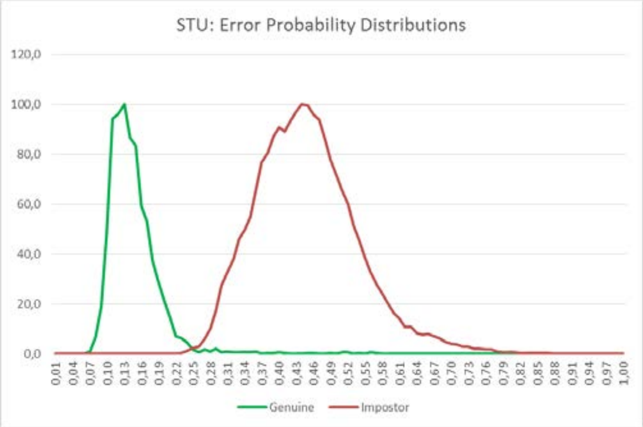
Level completed. Proceed to next level.

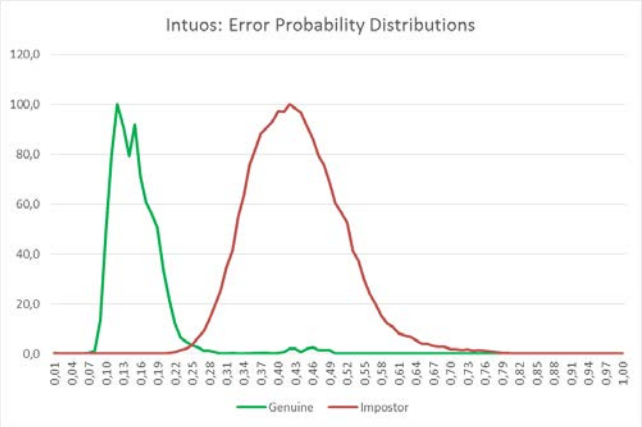
BASELINE: GENUINE DATABASE

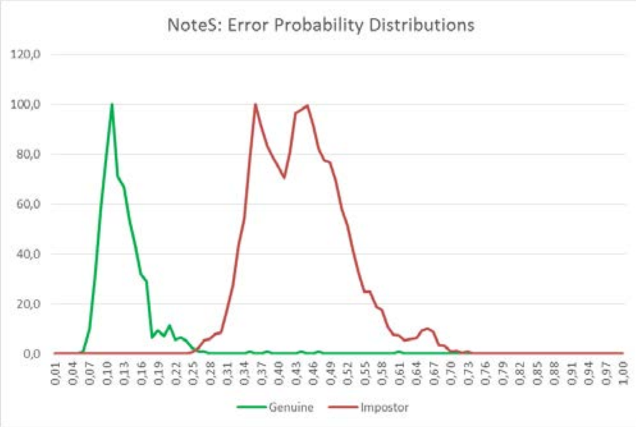
- Real Signatures
- Multi-device:
  - STU
  - Intuos
  - BlackBerry
  - iPad
  - Note (stylus)
- 49 people
- 60 signatures per device
- Biometric reference with the 3 first samples

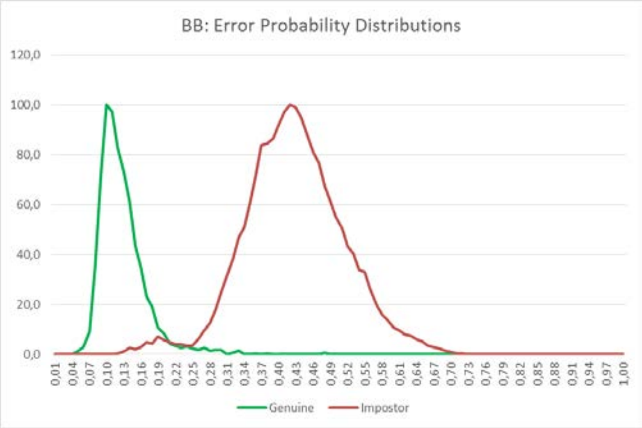
BASELINE: GENUINE DATABASE

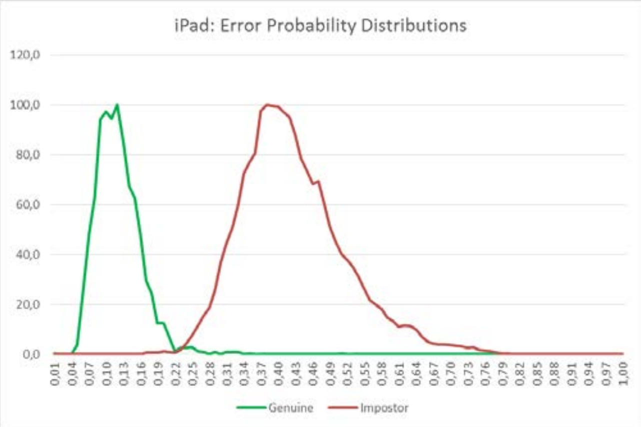
- EERs: STU (1.4%), Intuos (2.3%), Note-S (0.6%), iPad (0.8%), BB (2.3%)









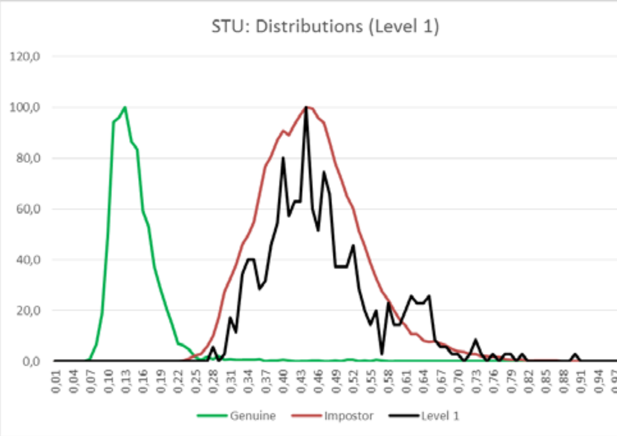


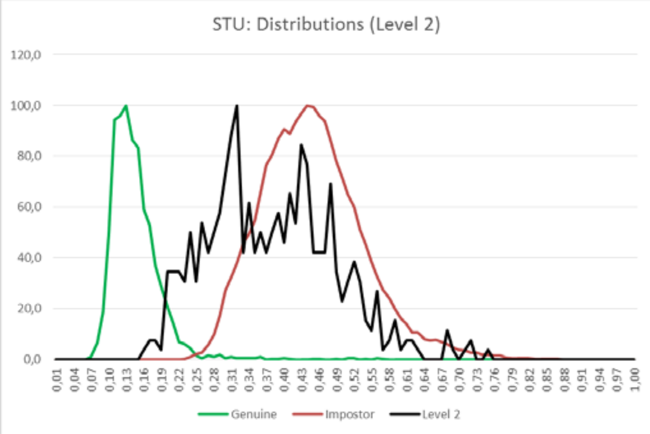
FORGERY LEVEL IMPACT

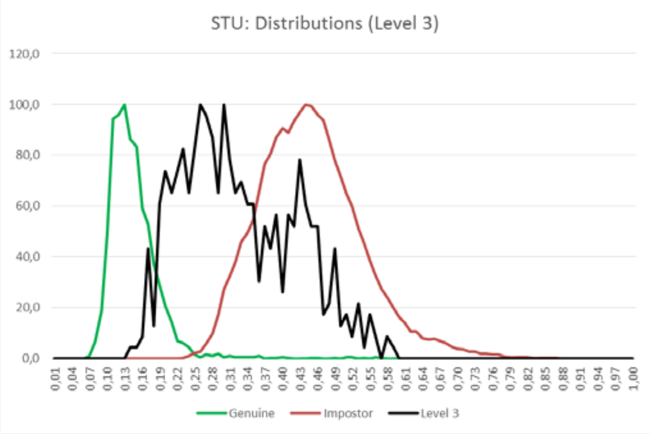
- Forgers had to forge, at least, 10 unknown users
- For each level, the forger had to validate 5 forgeries.
  - For each forgery the forger is allowed to use as many attempts as possible
  - No feedback is provided to the forger about each of those attempts.
- Threshold at EER:
  - FPADER (False Presentation Attack Detection Error Rate) = % of forgeries considered as genuine

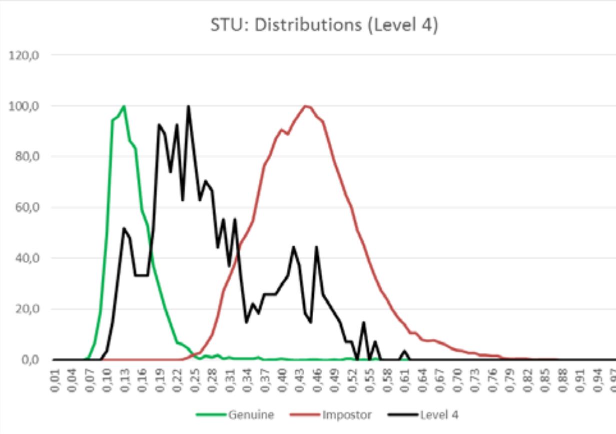
FORGERY LEVELS (STU)

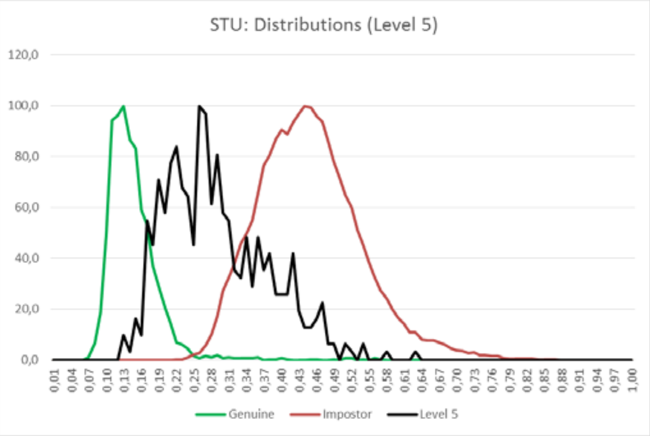
- L1 (0.4%), L2 (20.6%), L3 (40.8%), L4 (60.9%), L5 (55.1%), L6 (61.3%), L7 (81.3%)

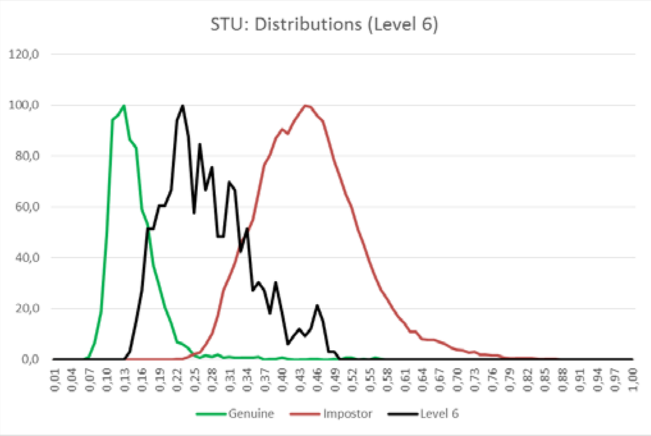


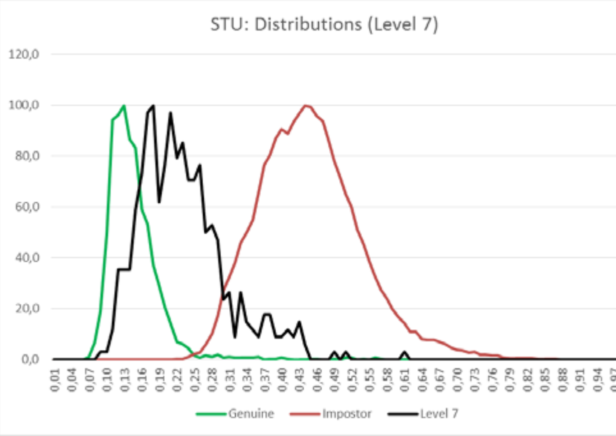






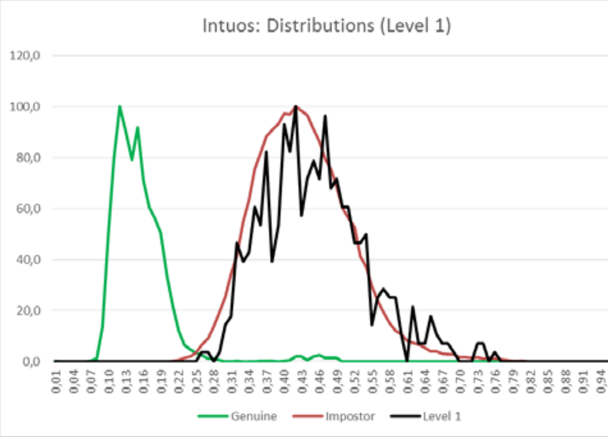


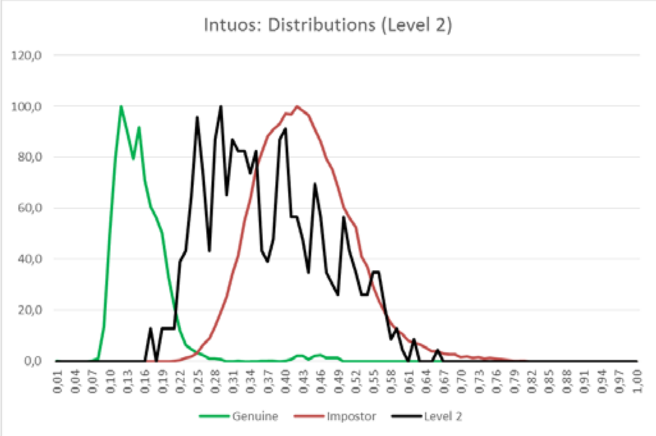


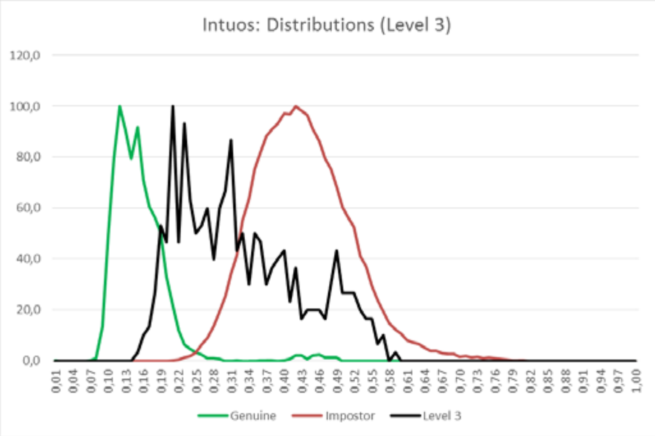


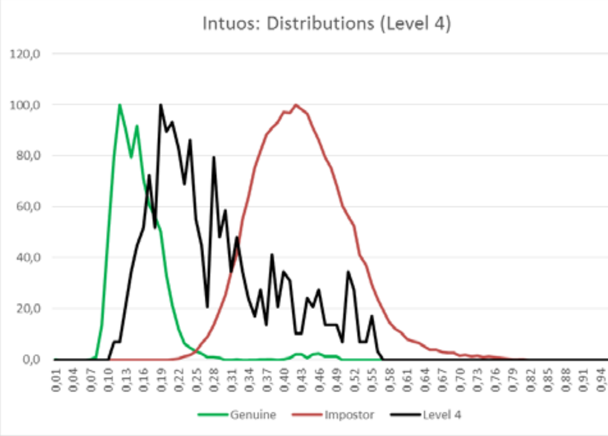
FORGERY LEVELS (INTUOS)

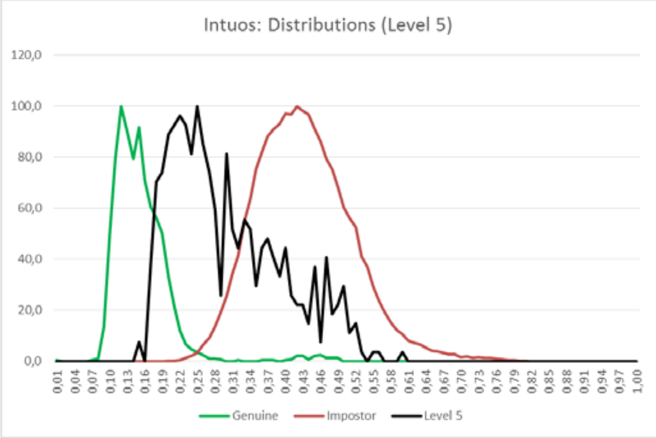
- L1 (0.4%), L2 (23.7%), L3 (40.7%), L4 (60.0%), L5 (53.5%), L6 (52.9%), L7 (72.2%)

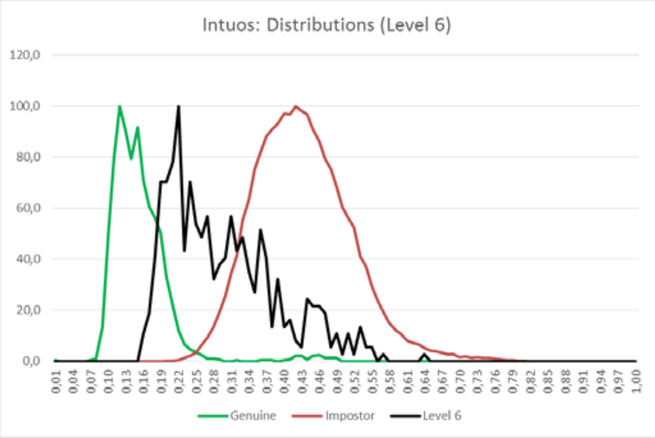

Intuos: Distributions (Level 1)

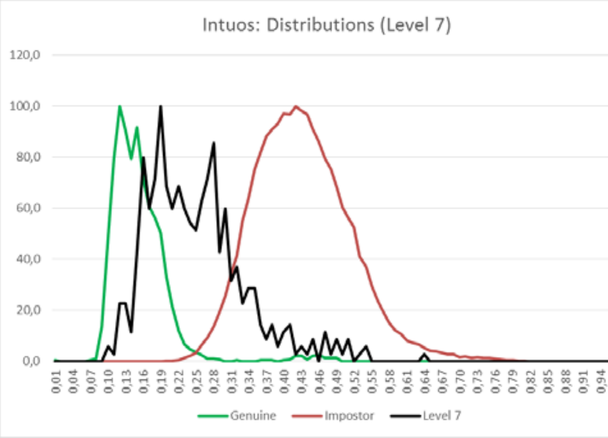

Intuos: Distributions (Level 2)


Intuos: Distributions (Level 3)


Intuos: Distributions (Level 4)

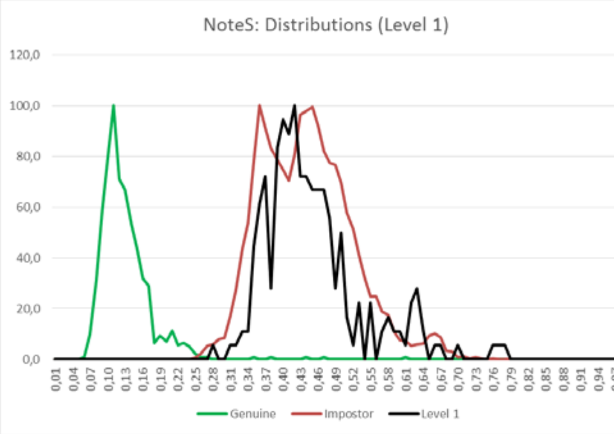

Intuos: Distributions (Level 5)

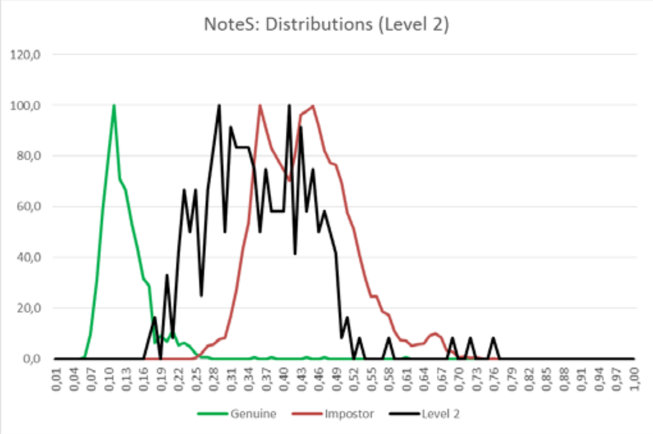

Intuos: Distributions (Level 6)

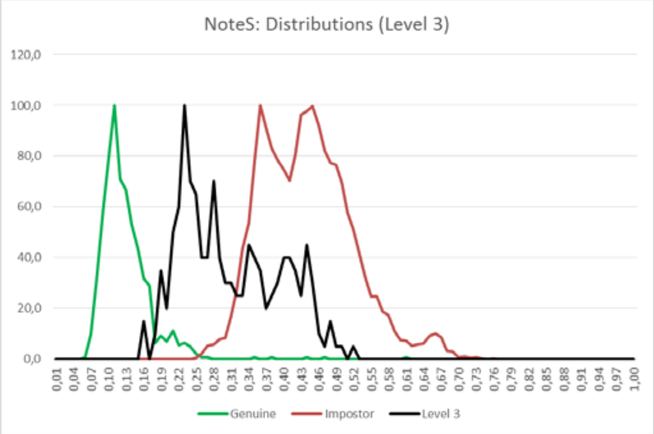

Intuos: Distributions (Level 7)

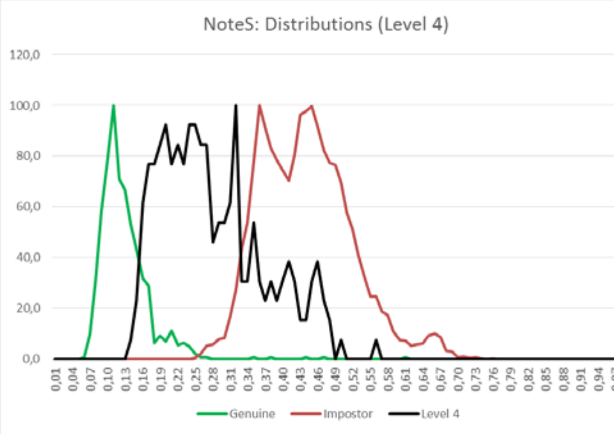
FORGERY LEVELS (NOTE-S)

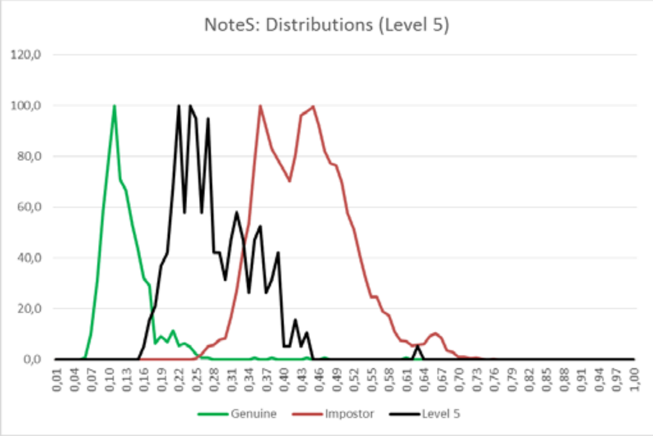
- L1 (0.0%), L2 (19.5%), L3 (42.8%), L4 (56.2%), L5 (56.2%), L6 (55.7%), L7 (78.4%)

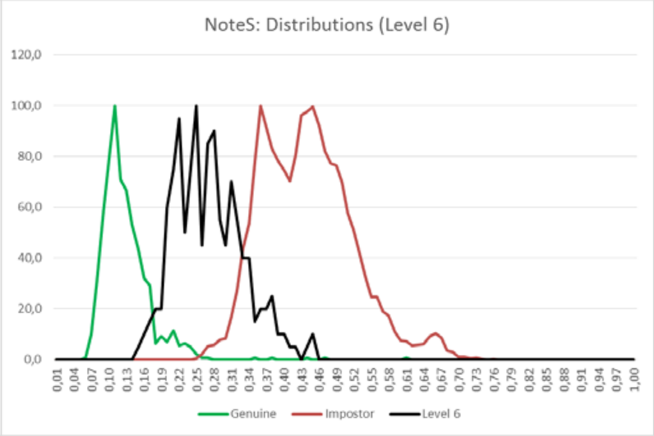

NoteS: Distributions (Level 1)

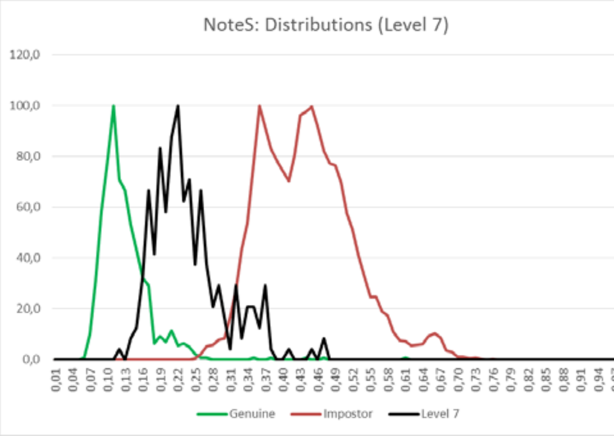

NoteS: Distributions (Level 2)


NoteS: Distributions (Level 3)


NoteS: Distributions (Level 4)

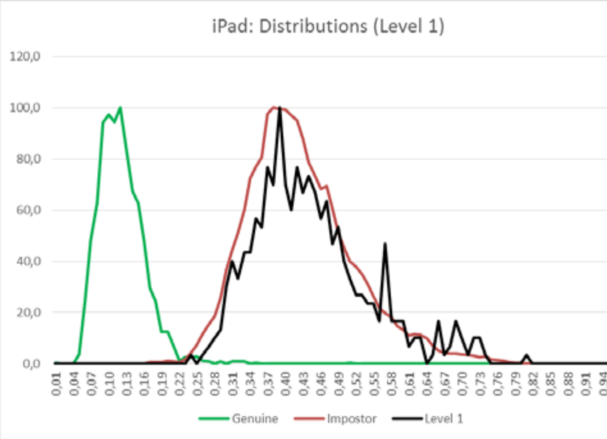

NoteS: Distributions (Level 5)

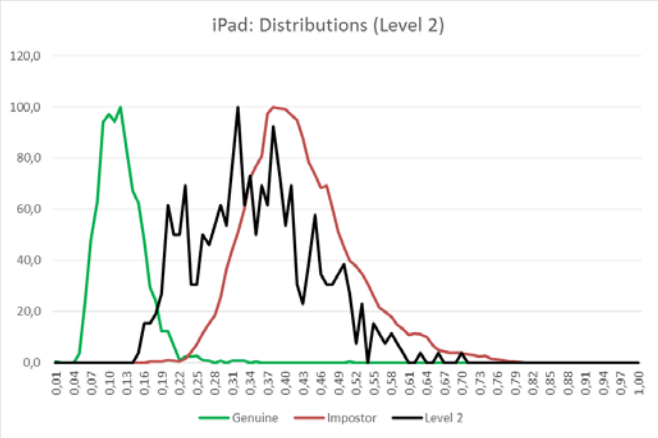

NoteS: Distributions (Level 6)

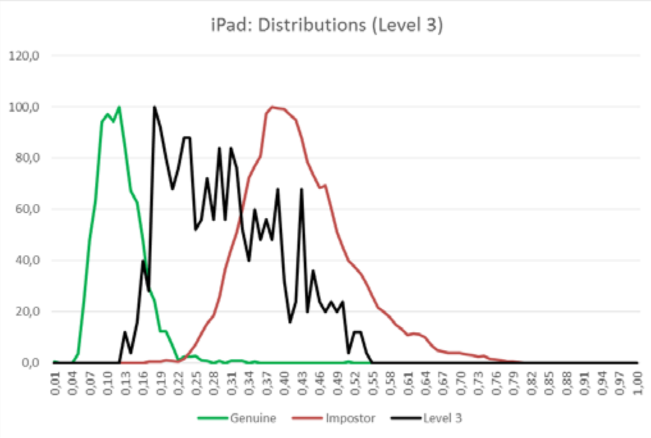

NoteS: Distributions (Level 7)

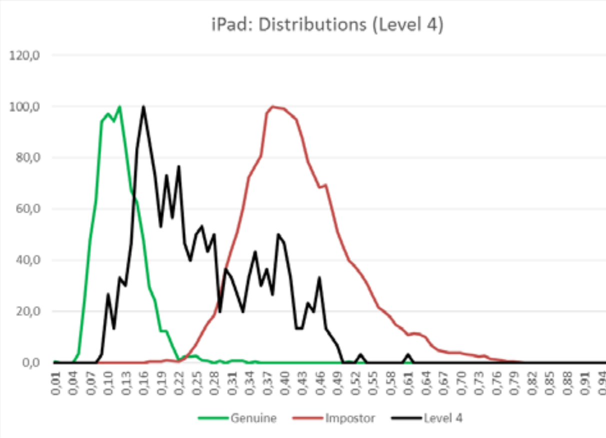
FORGERY LEVELS (IPAD)

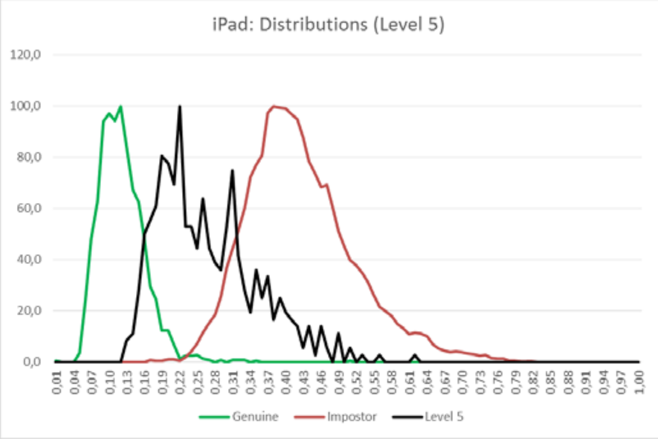
- L1 (0.2%), L2 (20.0%), L3 (38.4%), L4 (55.3%), L5 (51.4%), L6 (58.0%), L7 (72.7%)

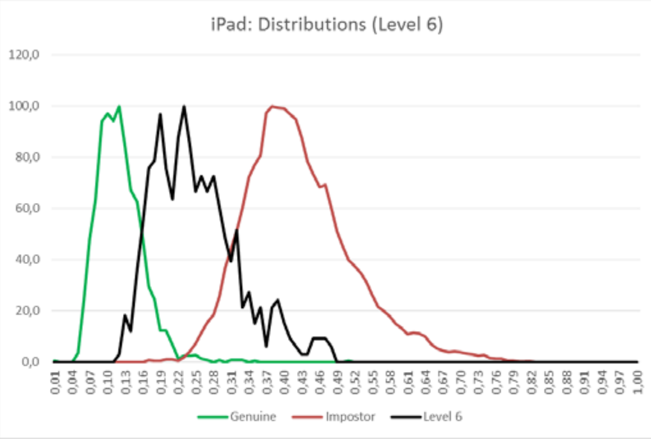


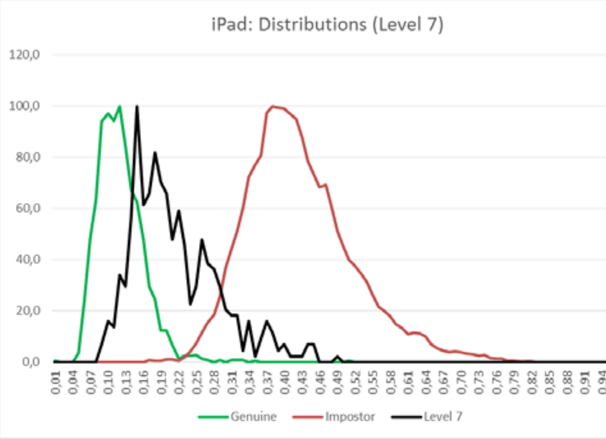






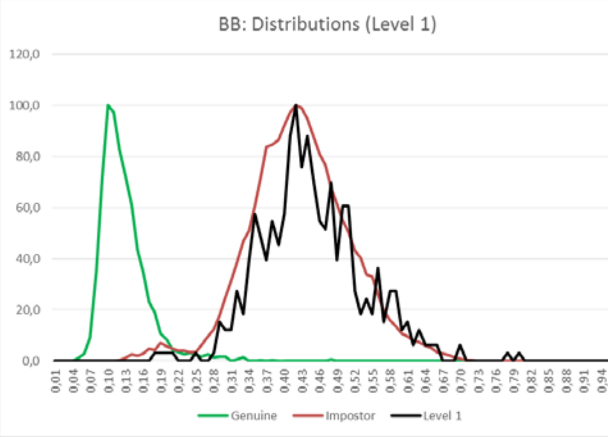




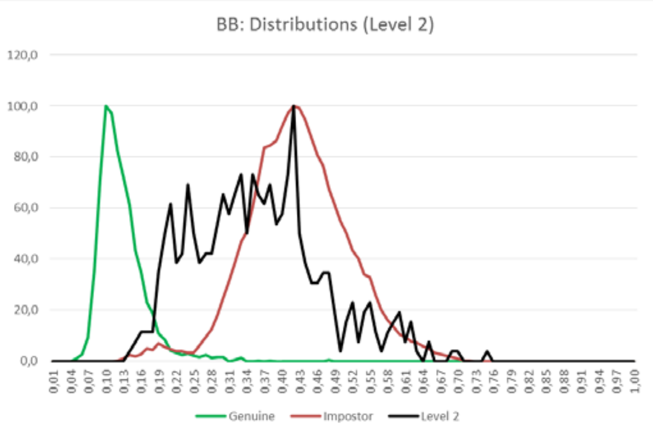


FORGERY LEVELS (BB)

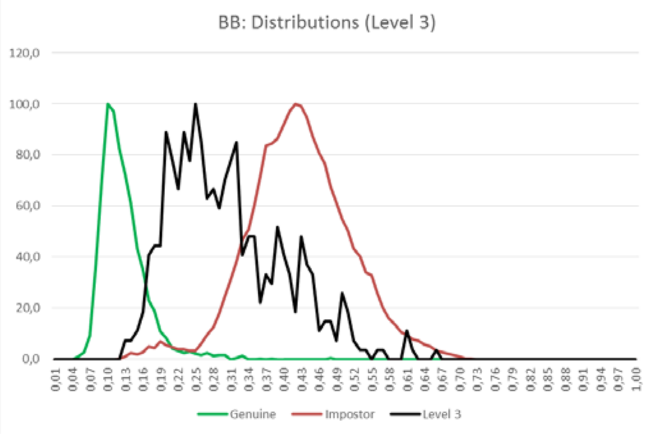
- L1 (0.8%), L2 (14.6%), L3 (27.6%), L4 (50.5%), L5 (40.3%), L6 (43.0%), L7 (64.0%)



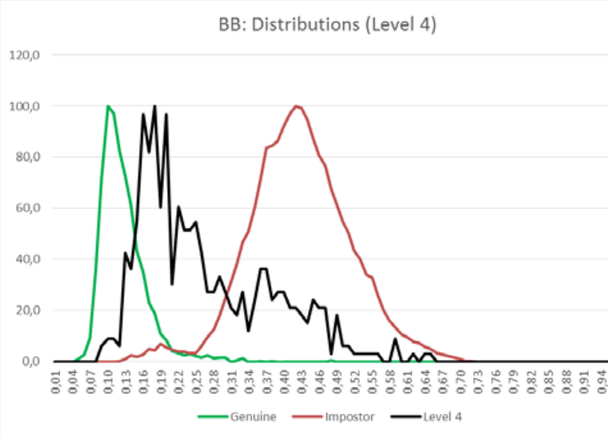
BB: Distributions (Level 1)



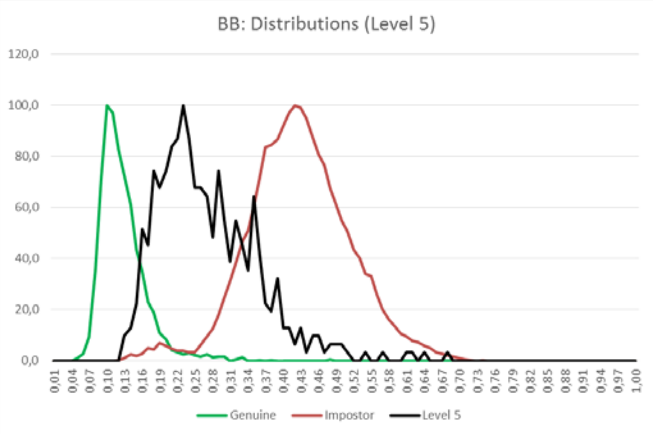
BB: Distributions (Level 2)



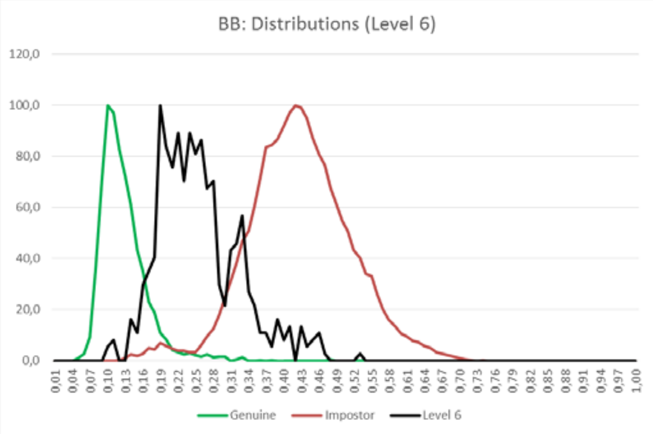
BB: Distributions (Level 3)



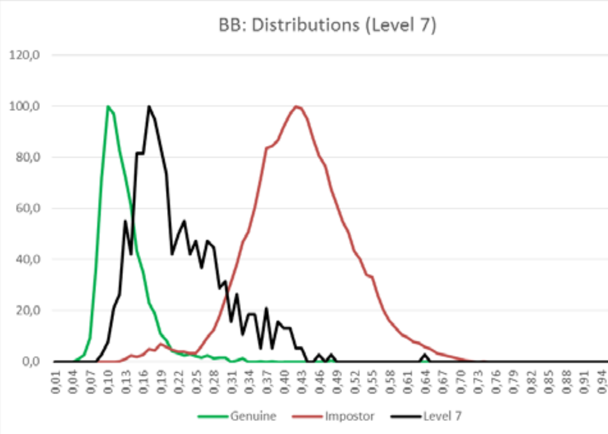
BB: Distributions (Level 4)



BB: Distributions (Level 5)



BB: Distributions (Level 6)



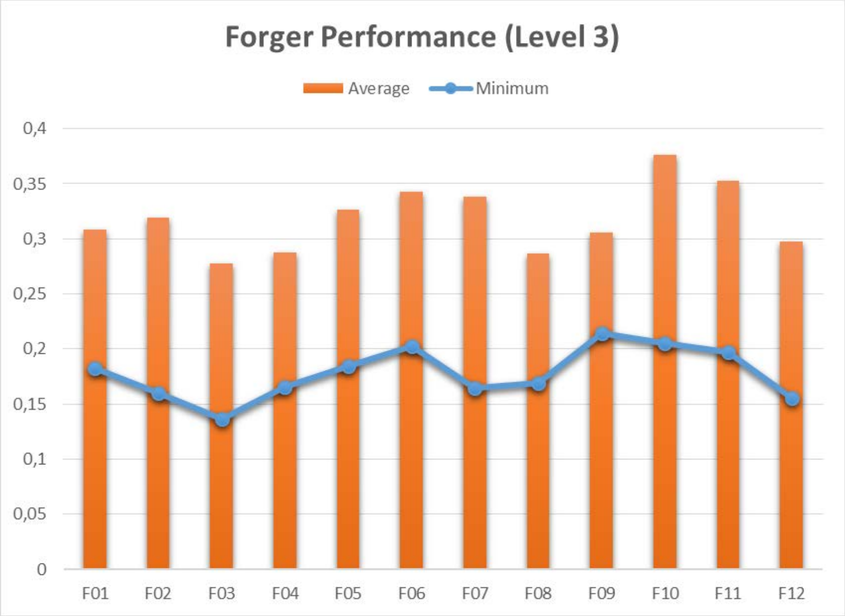
BB: Distributions (Level 7)

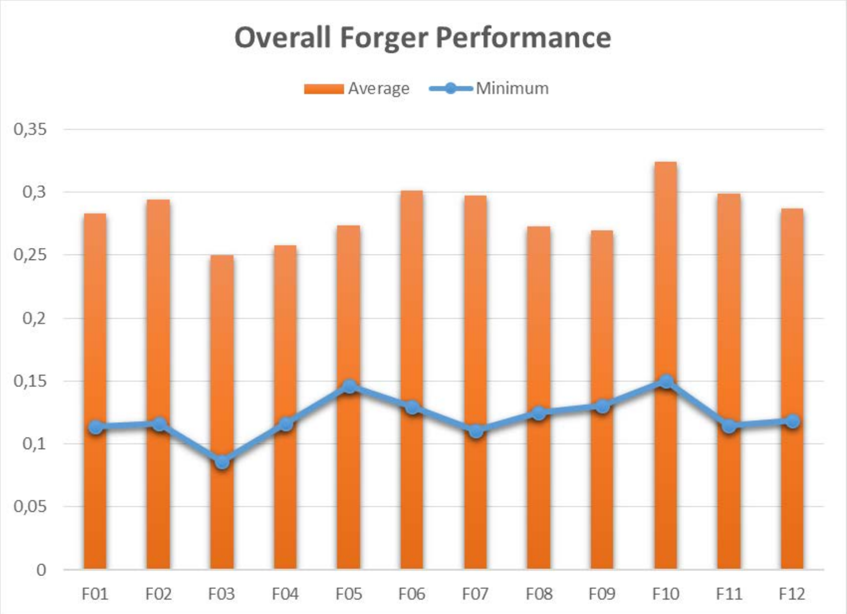
FORGERY LEVEL IMPACT

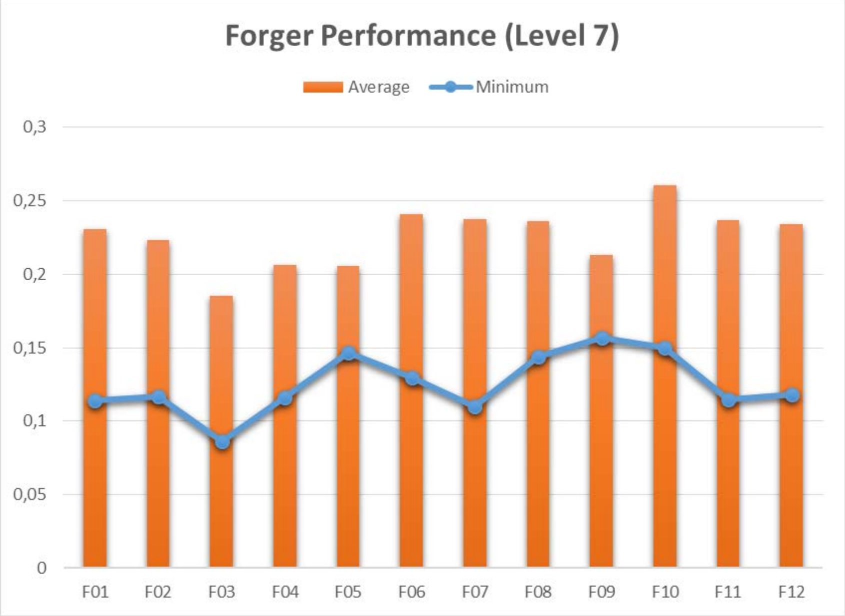
- Behaviour is common to all devices:
  - Results seem to be dependent purely on the algorithm
  - Not dependency on whether the signature is done:
    - With a stylus or with the finger
    - In a professional Tablet, in a Smartphone or in a Tablet
- Major success in achieving forgeries when:
  - Having a static view of the signature
  - Using carbon copy
- Dynamic knowledge improves forgery
  - But not as much as expected
    - Is the algorithm really analysing the dynamics
  - But a non-professional forger obtain excellent results

FORGER PERFORMANCE

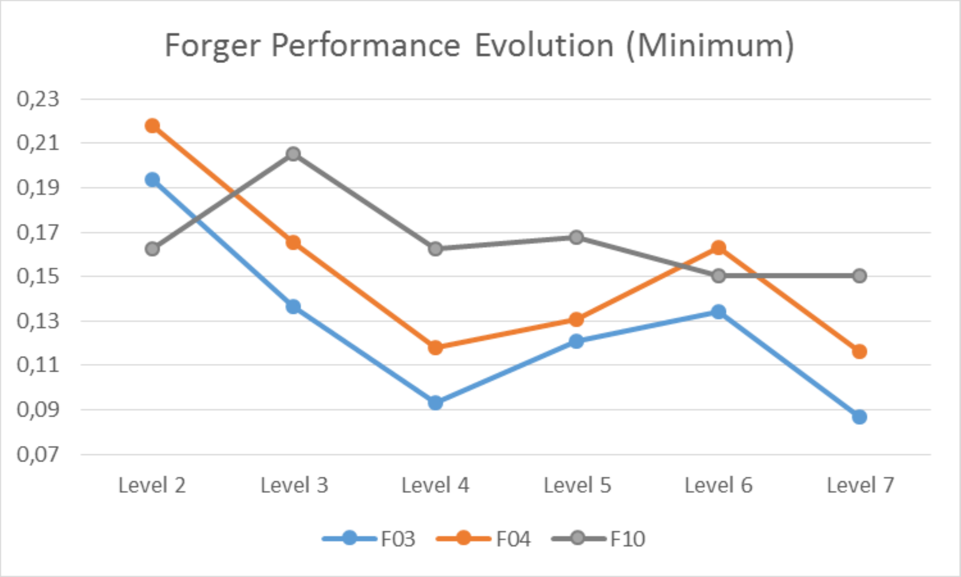
- Level 3:
  - Minimum: F03, F12, F02
  - Average: F03, F08, F04
- Level 7:
  - Minimum: F03, F07, F01
  - Average: F03, F05, F04
- Overall:
  - Average: F03, F04, F09

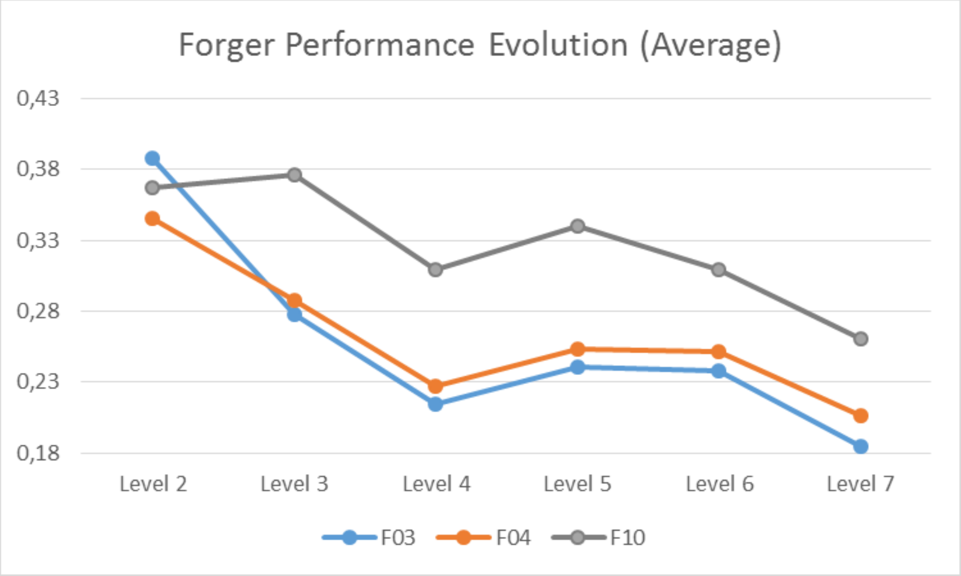






FORGER PERFORMANCE

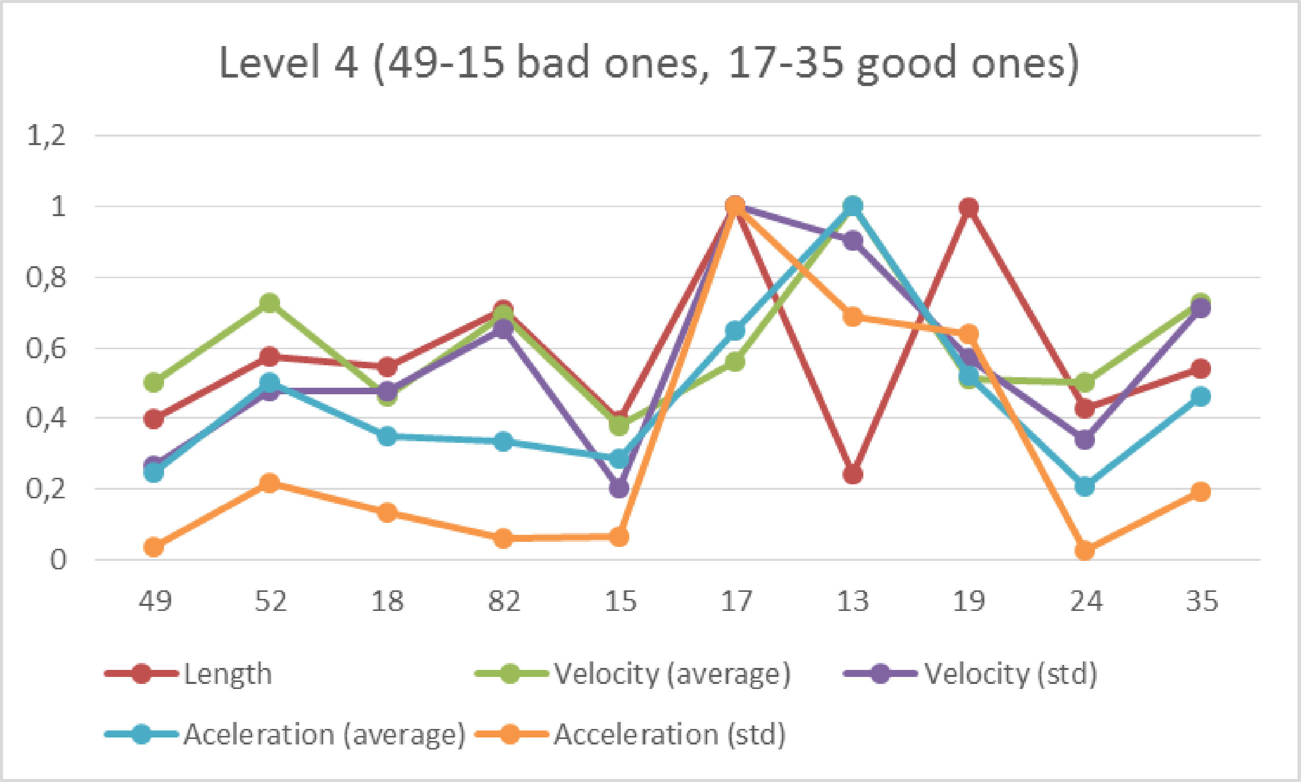




SIGNATURE ROBUSTNESS

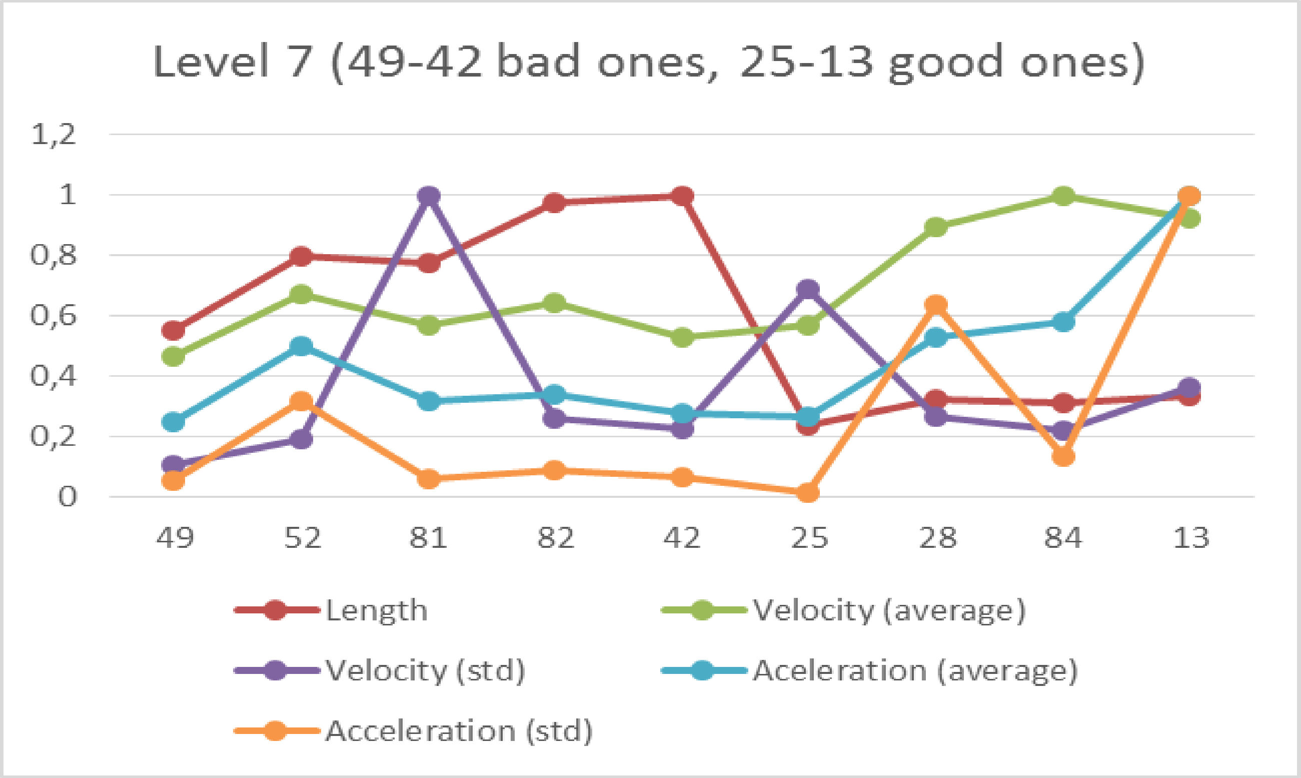
- With all this information, is it possible to conclude some tendency for the “robustness” (or quality) of the signatures?
- It has been taken the users within the 30 best and worst distances
  - Level 4 (only providing static information to the forger)
  - Level 7 (after providing dynamic information to the forger)
- Parameters analysed:
  - Length
  - Velocity (average and std)
  - Acceleration (average and std)

SIGNATURE ROBUSTNESS (L4)



- Not solid conclusion as good ones may have the same values as bad ones!
  - Further analysis to be done

SIGNATURE ROBUSTNESS (L7)



- Tendency for improvement with shorter signatures (??)
- Slight improvement with average acceleration
- Questionable tendency when increasing acceleration std

SIGNATURE ROBUSTNESS

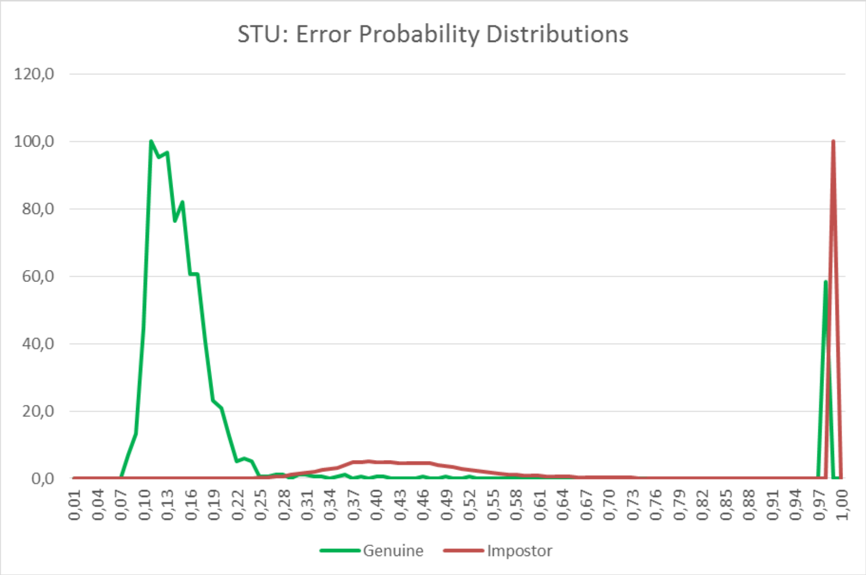
- Not having objective metrics working, how about analysing the signatures subjectively?
- Level 4 (only static information):
  - The worst ones seem to have:
    - Easy to understand drawing (e.g. names clearly written)
    - Conventional writing flow
    - Conventional aspect ratio as of regular writing
  - The best ones are:
    - Complex in strokes and superposition of strokes
    - Not understandable (i.e. only abstract strokes)
    - Not conventional writing flow
- Level 7 (dynamics added):
  - The worst ones present the same characteristics of those at Level 4, but now without the "protection" of non-conventional writing flow
  - The best ones are:
    - Not showing understandable letters
    - Variable and non conventional proportions
    - Some of them even look very simple in drawing
- Are these results dependent on the forger and/or algorithm?

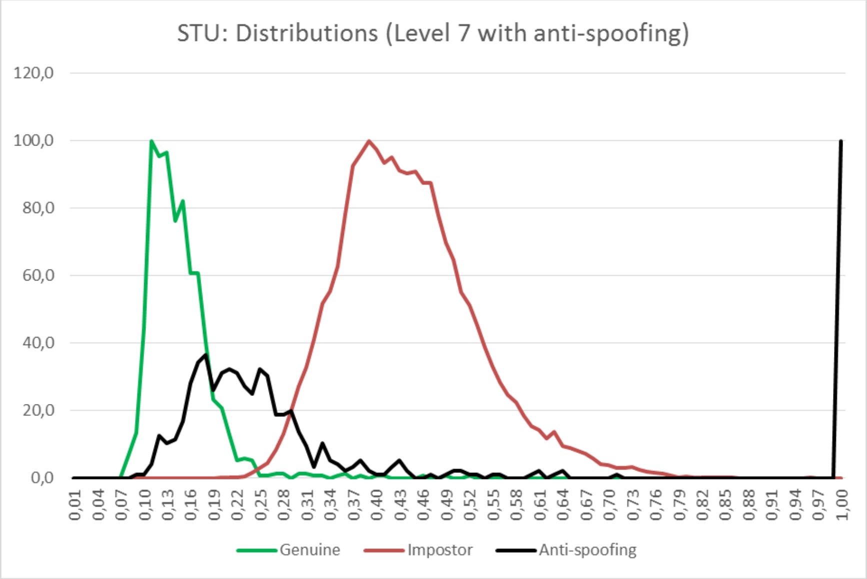
ANTI-SPOOFING INFLUENCE

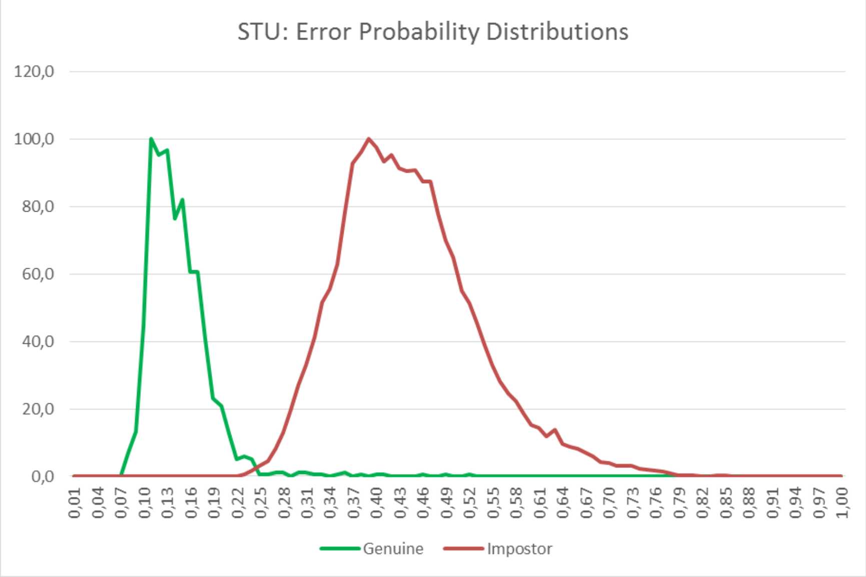
- Just with the results on the different levels (just the graphics and numbers, not the forgeries), the manufacturer provided a new version of the algorithm with some anti-spoofing mechanisms implemented.
- If the signature was detected as a potential forgery, the system responded with an "artificial score" of 1 (i.e. maximum distance)
  - Request made by the laboratory
- The evaluation was carried out with the same databases:
  - Genuines / Impostors
  - Forgeries (i.e. attacks)

ANTI-SPOOFING INFLUENCE

- Changes in Algorithm Performance:
  - 7.1% of False PAD
  - 48.8% of True Zero-Effort PAD
  - EER with PAD rejections increased to 7.8%
  - EER without PAD rejections (e.g. taken as FTA) = 1.2% (<1.4%)
- Real forgeries detection:
  - 15.7% True PAD

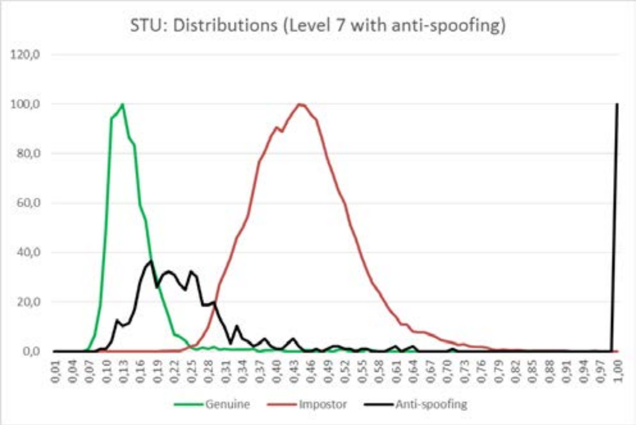

STU: Error Probability Distributions

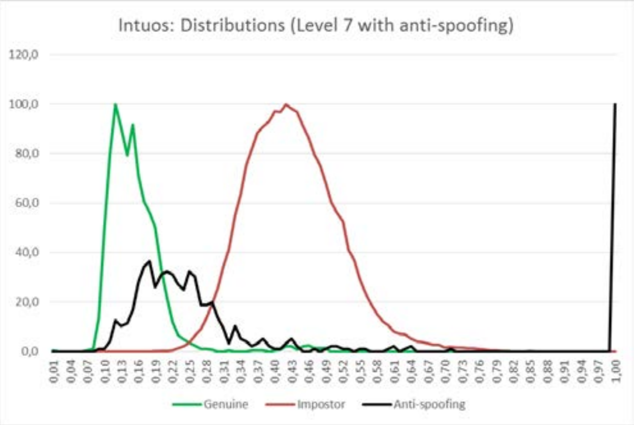

STU: Distributions (Level 7 with anti-spoofing)

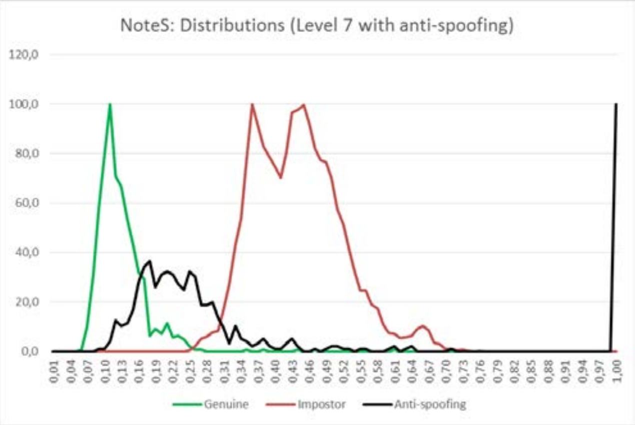

STU: Error Probability Distributions

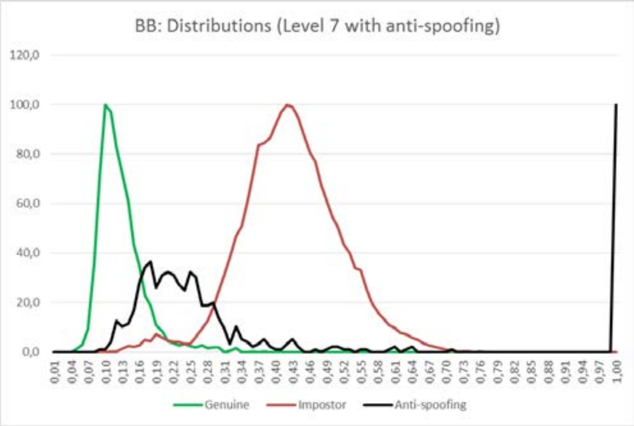
ANTI-SPOOFING INFLUENCE

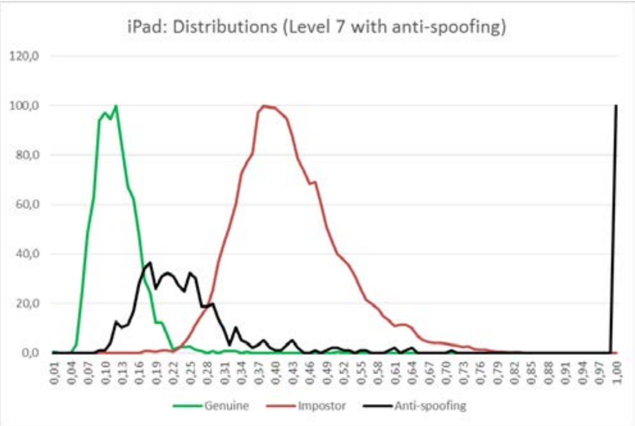
- FPADER:
  - STU (67.3%) Intuos (67.3%), Note-S (64.4%), iPad (56.7%), BB (47.7%)


STU: Distributions (Level 7 with anti-spoofing)


Intuos: Distributions (Level 7 with anti-spoofing)


NoteS: Distributions (Level 7 with anti-spoofing)


BB: Distributions (Level 7 with anti-spoofing)


iPad: Distributions (Level 7 with anti-spoofing)

CONCLUSIONS

- A tool to evaluate forgeries in handwritten signature has been created
  - Exploiting the different knowledge of the forger
- For the algorithm evaluated:
  - Behaviour is independent of the capture device
  - Major success in achieving forgeries with carbon-copy (is it really a threat?) and with the single static information
  - Dynamic knowledge improves forgery, but not as much as expected
    - Some signatures get benefit of this being protected by non-conventional writing
- Robustness of the signature seems to increase with the lack of use of recognizable letters and non-conventional aspect ratio
- Anti-spoofing mechanisms, impact seriously on the behaviour of the algorithm
  - At least it increases the FTA (or equivalent rate)
  - They reduce FPADER, but its impact may be questionable
- The work done is dependent on the algorithm tested and the forgers used
  - Future work in analysing that dependency

THANKS!
QUESTIONS?

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