Integration of Pore Characteristics into the Evaluation of Fingerprint Evidence

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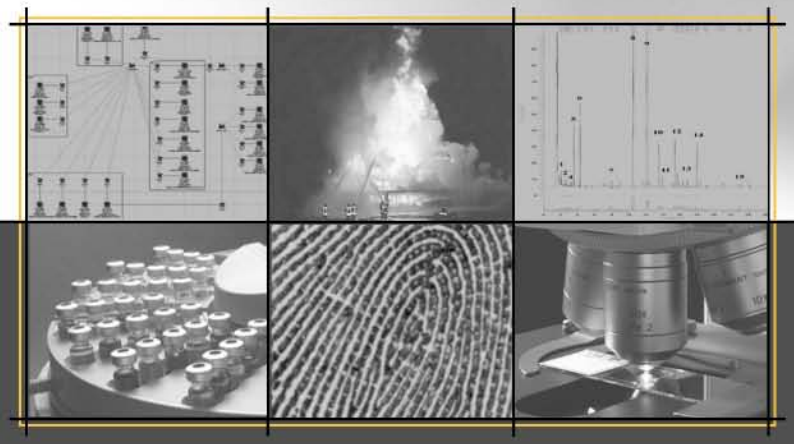

R. A. Reiss

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Objectives of the research

- Design a model to assess the contribution of pores in the fingerprint comparison process
  - Account for both within and between fingers variability
  - Using an approach based on Likelihood Ratios (LRs) to carry out the integration of pores in a framework including 1st and 2nd level details

What is the probability of the evidence (*E*) *if* (|) the mark and the print have a common source (H_p)?

Within source variability of marks/prints

Time, substrate, clarity, distortion

Between sources variability of marks/prints

Selectivity of the features among friction ridge skin impressions

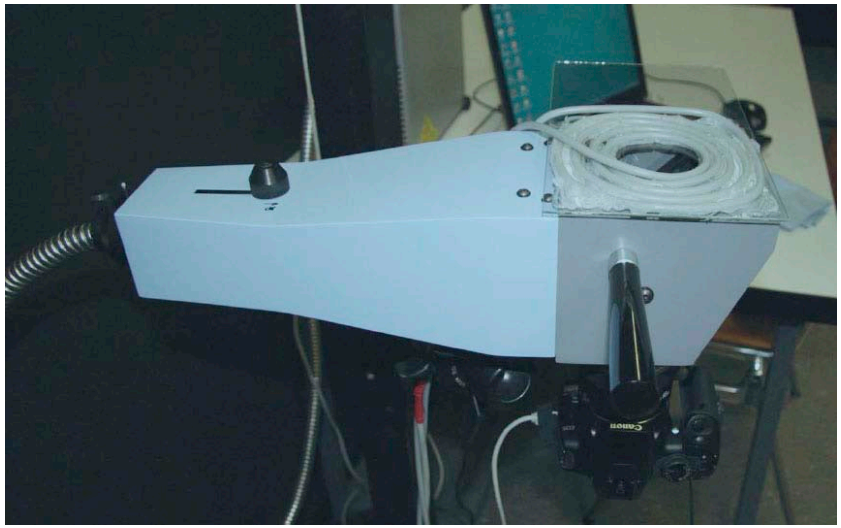
What is the probability of the evidence (*E*) *if* (|) an unknown person left the mark (H_d)?

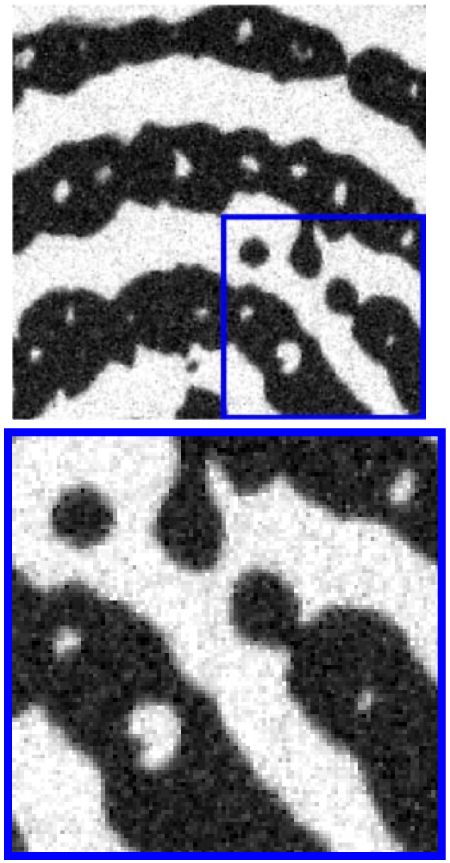
Objectives of the research

- Design an algorithm to automatically extract pores
- Define a metric able to highlight the similarities and dissimilarities between sets of pores

Data acquisition

- Acquisition of databases for within and between variability





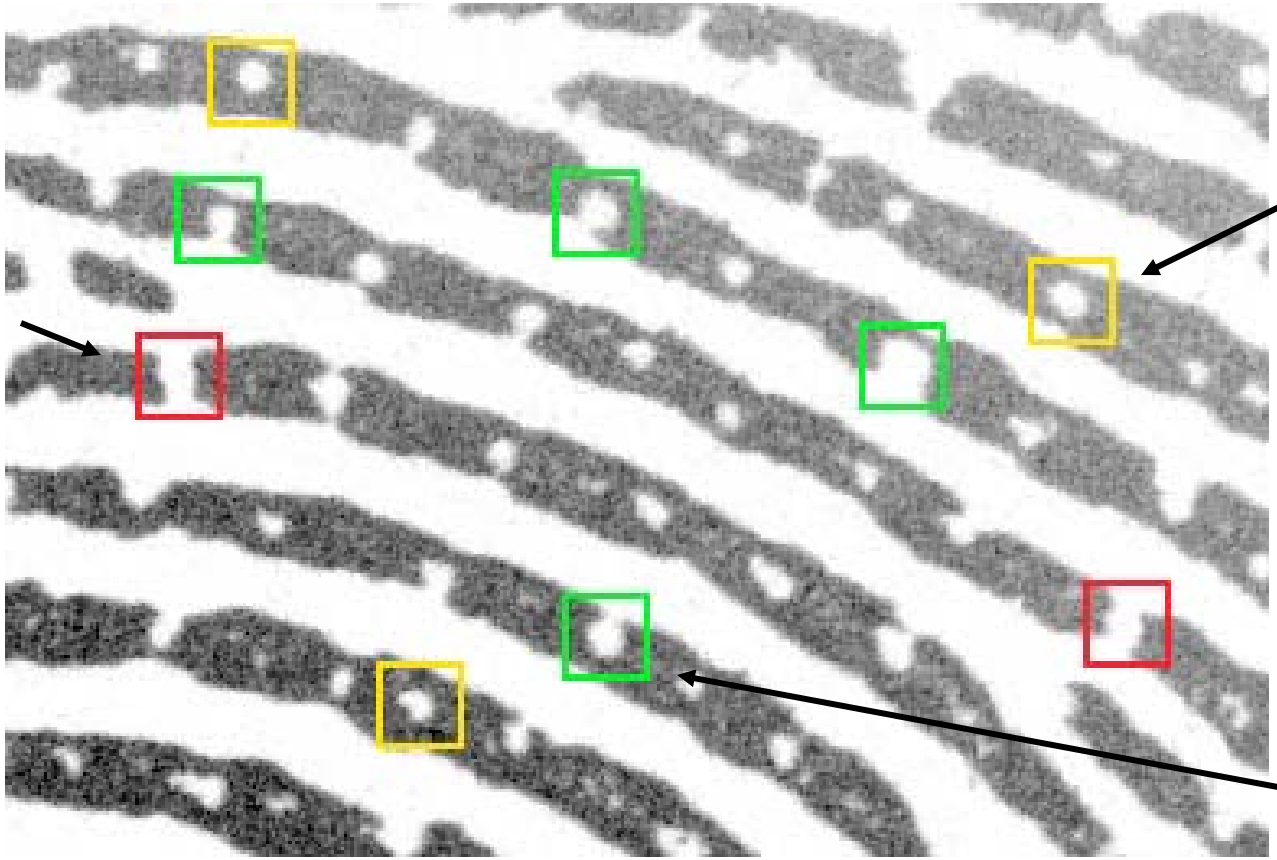
about 2700dpi resolution

Data acquisition

- L3 database for between variability (L3BSDB)
  - 54 donors for **1,728 fingerprints**
  - 4 impressions of eight fingers
  - Captured without distortion
- L3 database for within variability (L3WSDB)
  - 14 donors for **756 fingerprints**
  - Recorded under various distortion and pressure conditions
  - 3 fingers / 9 distortions / 2 sessions

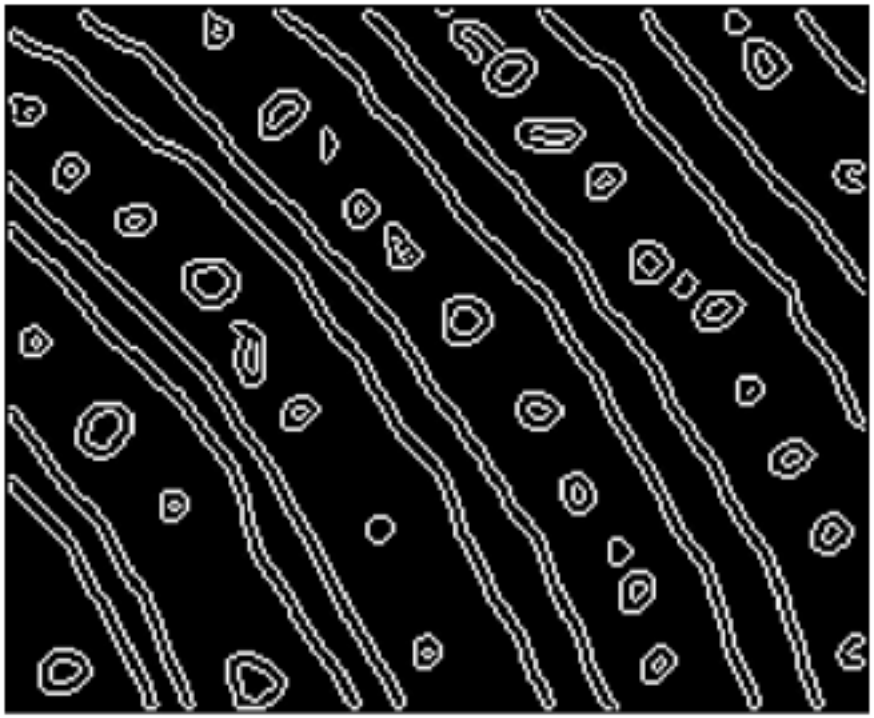
Level 3 characteristics extraction

- Pores extraction based on pore types:
  - Open (on one or two sides of the ridge) or Closed



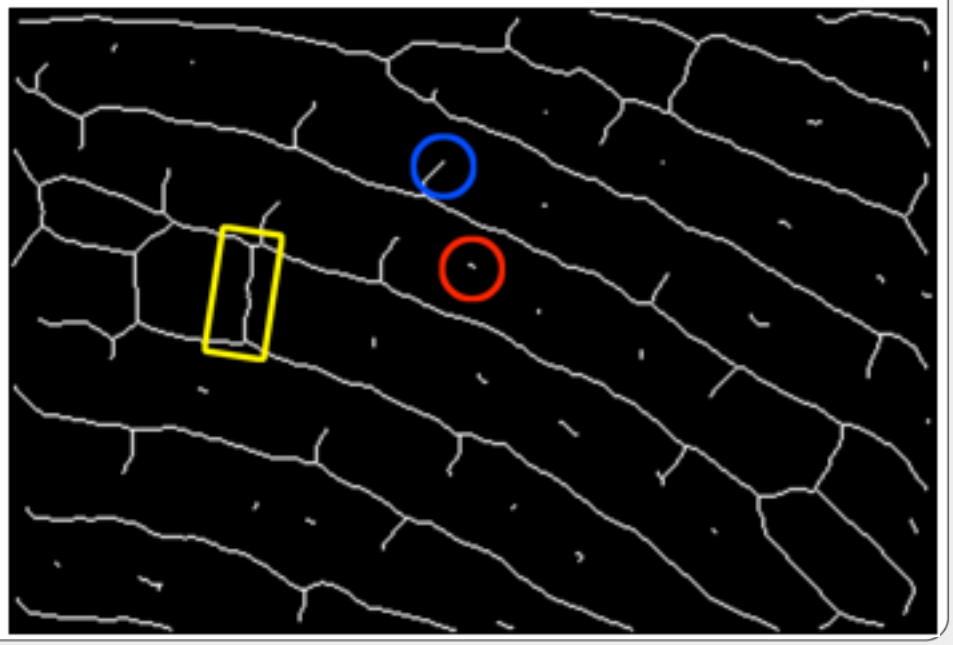
Level 3 characteristics extraction

- Closed pores
  - Edge detection (Canny filtering)
  - Heuristics applied to remove falsely detected pores

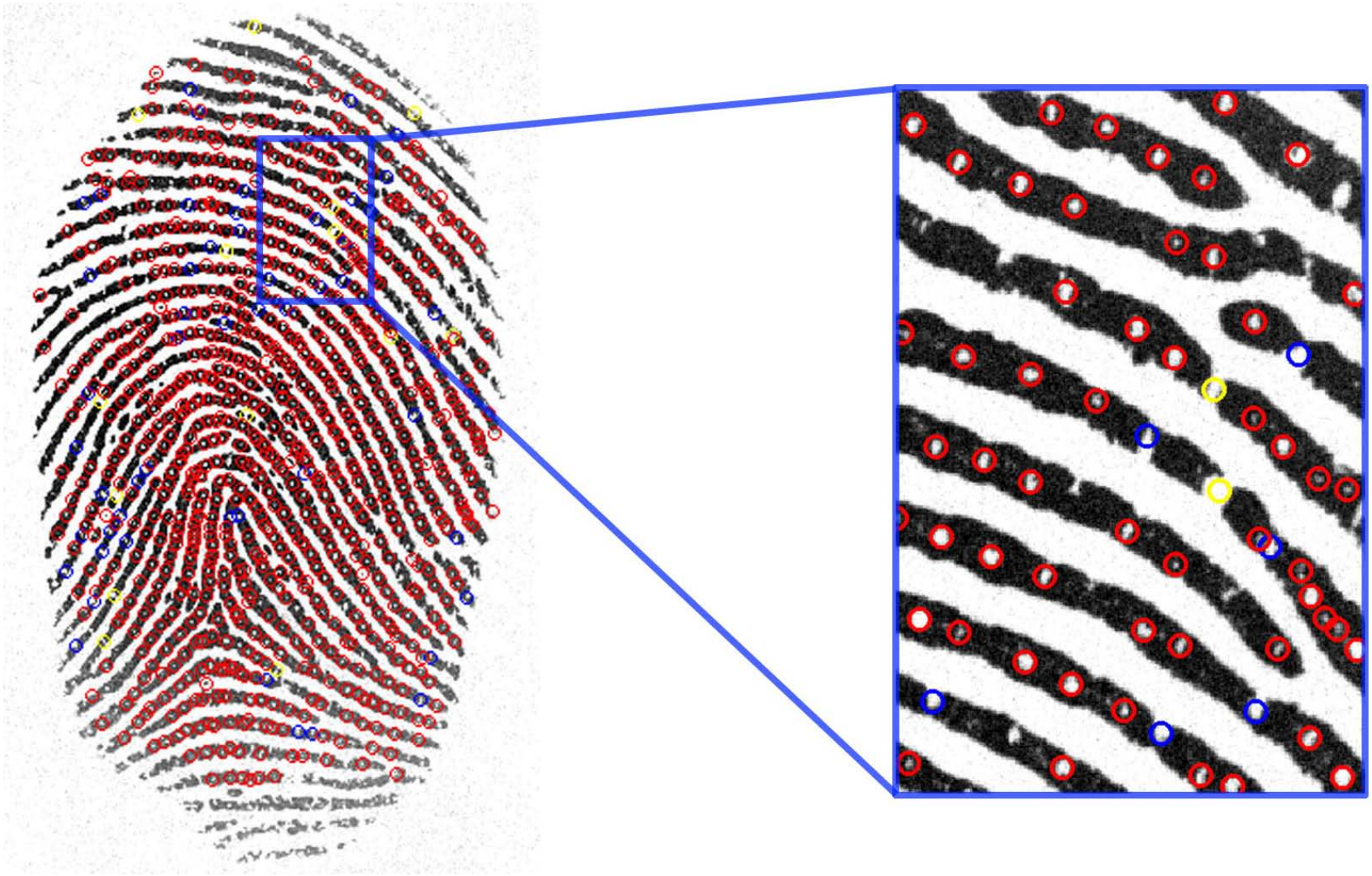


Level 3 characteristics extraction

- Open pores
  - Based on the skeletonization of the valleys
  - Detection of end and bifurcation pixels
  - Heuristics applied to remove falsely detected pores



Level 3 characteristics extraction



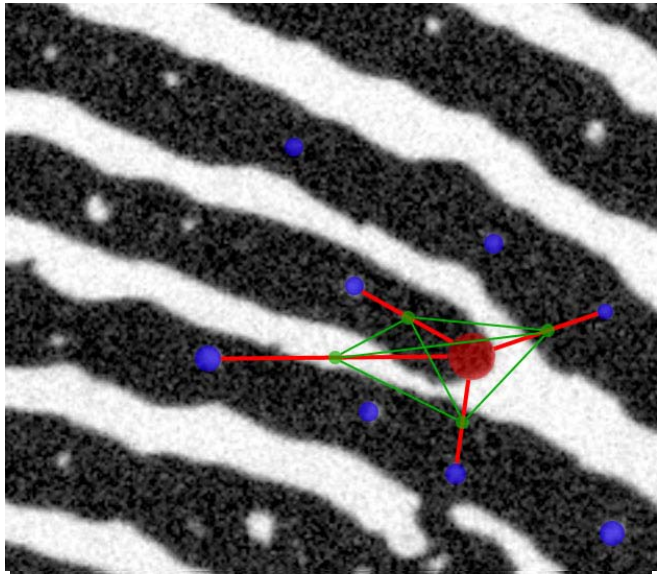
Metric for pores

- Measures on pores on a single ridge without any reference point were not effective
- Adding a reference point increased efficiency
  - One ridge poorly discriminating
  - Consecutive ridges considered

On adjacent ridges with a reference point

Metric for pores

- One metric based on three scores:
  - Based on distances between each pore and the minutia
  - Based on angles between each pair of consecutive matching segments
  - Based on the centre of mass of the remaining segments



Metric for pores

- Fusion of the three scores in a single score

or

LR computation

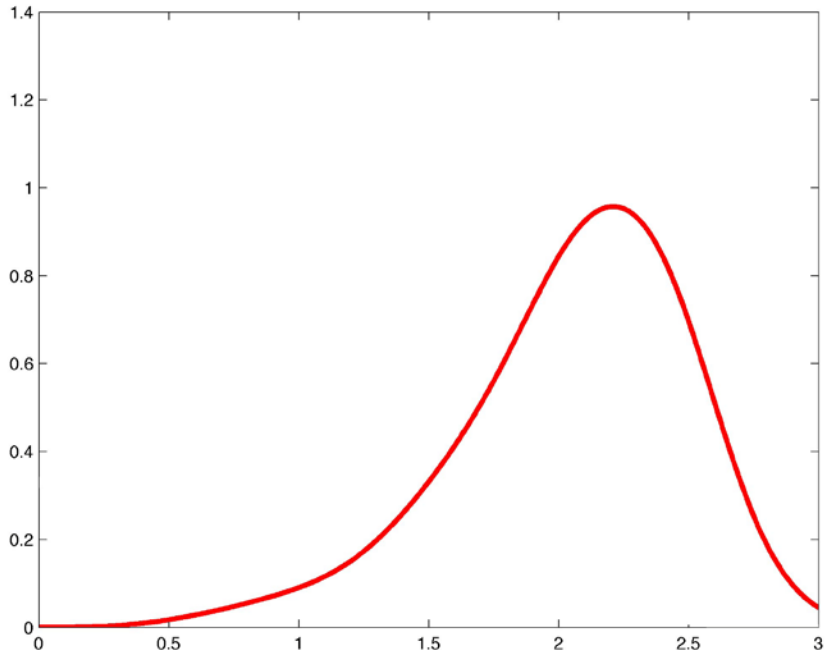
Samples from a zone

WI 1	WI 2	WI 3	WI 4	WI 5
WI 6	WI 7	WI 8	WI 9	WI 10
WI 11	WI 12	WI 13	WI 14	WI 15
WI 16	WI 17	WI 18	WI 19	WI 20
	WI 21	WI 22		

$M_{WI\ 5}$

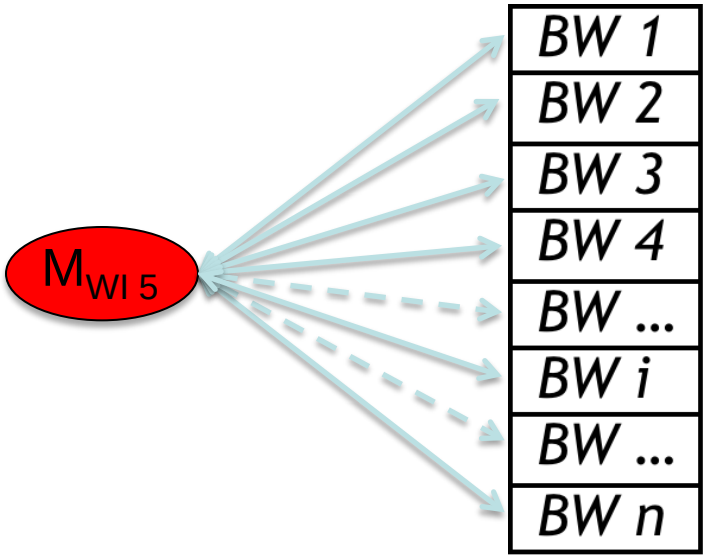
Within-variability

210 scores computed pairwise



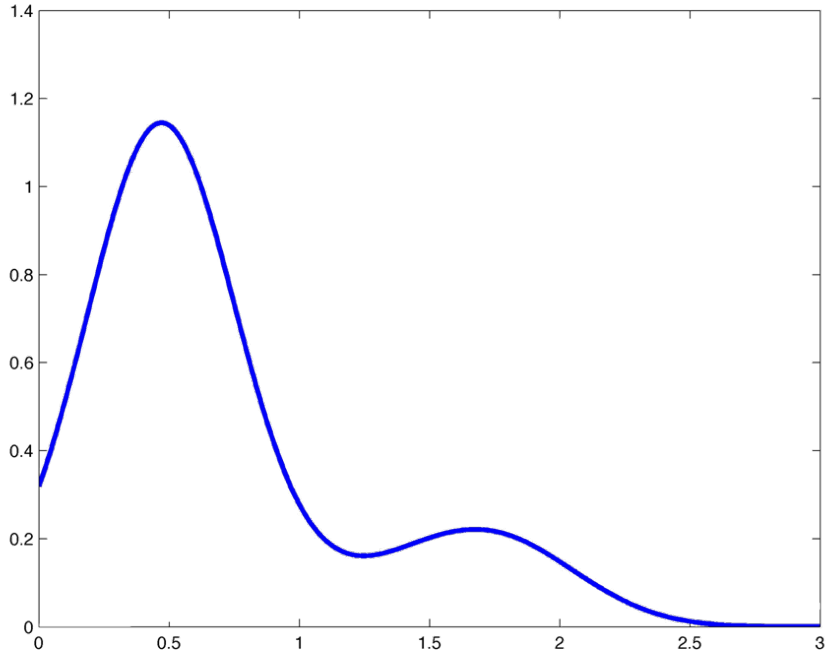
The density is estimated using a Gaussian Mixture Model

LR computation



Between-variability

n scores computed against samples coming from different sources



The density is estimated using a Gaussian Mixture Model

LR computation

> When H_p is true:

The mark is compared against a corresponding sample

We want to assess

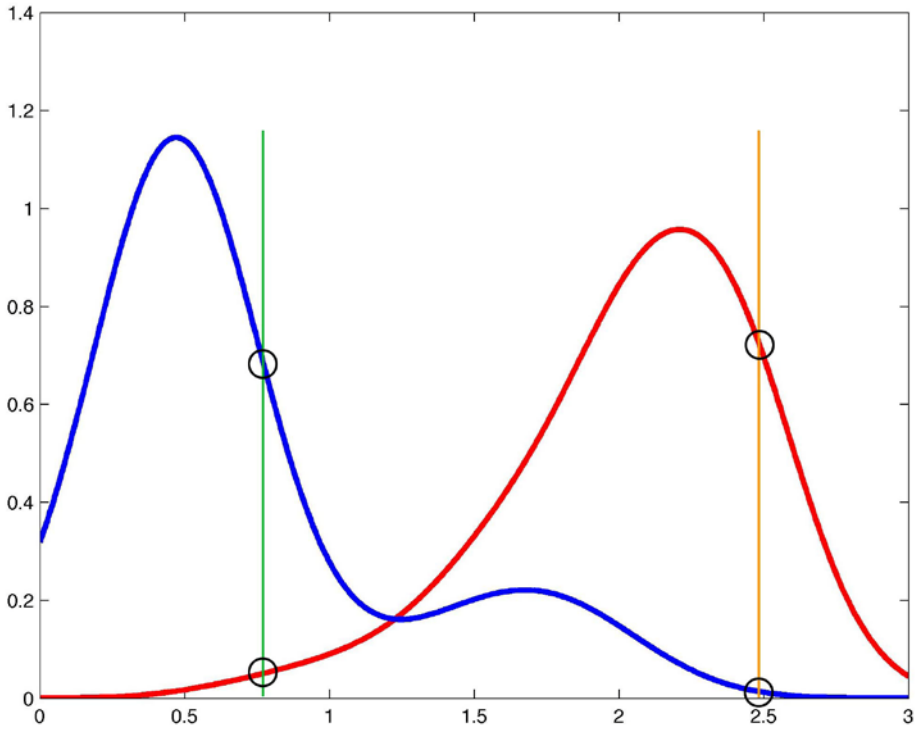
We call them **LR_{Hp}**

> When H_d is true:

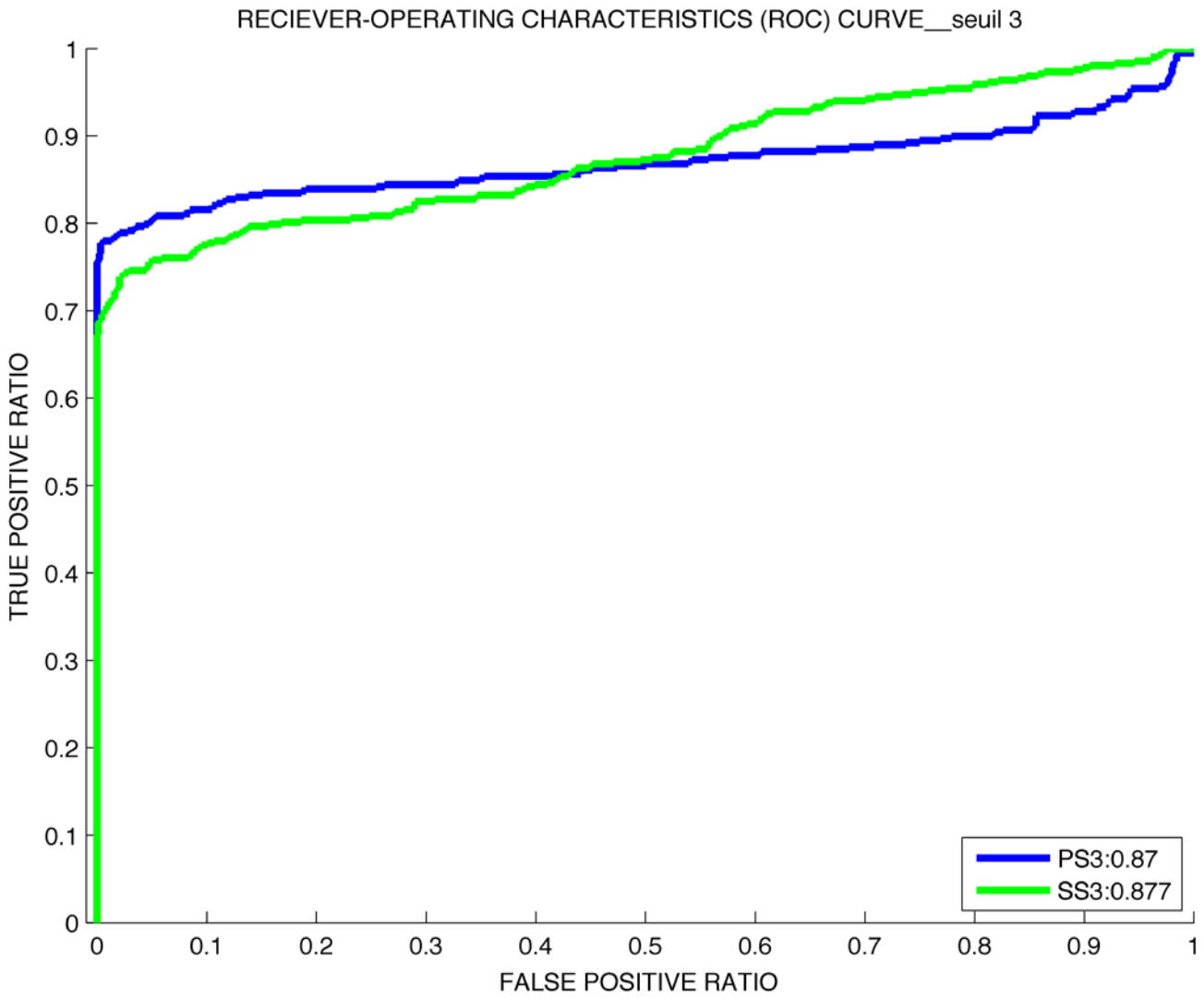
The mark is compared against a print taken at random in the non related samples

We call them **LR_{Hd}**

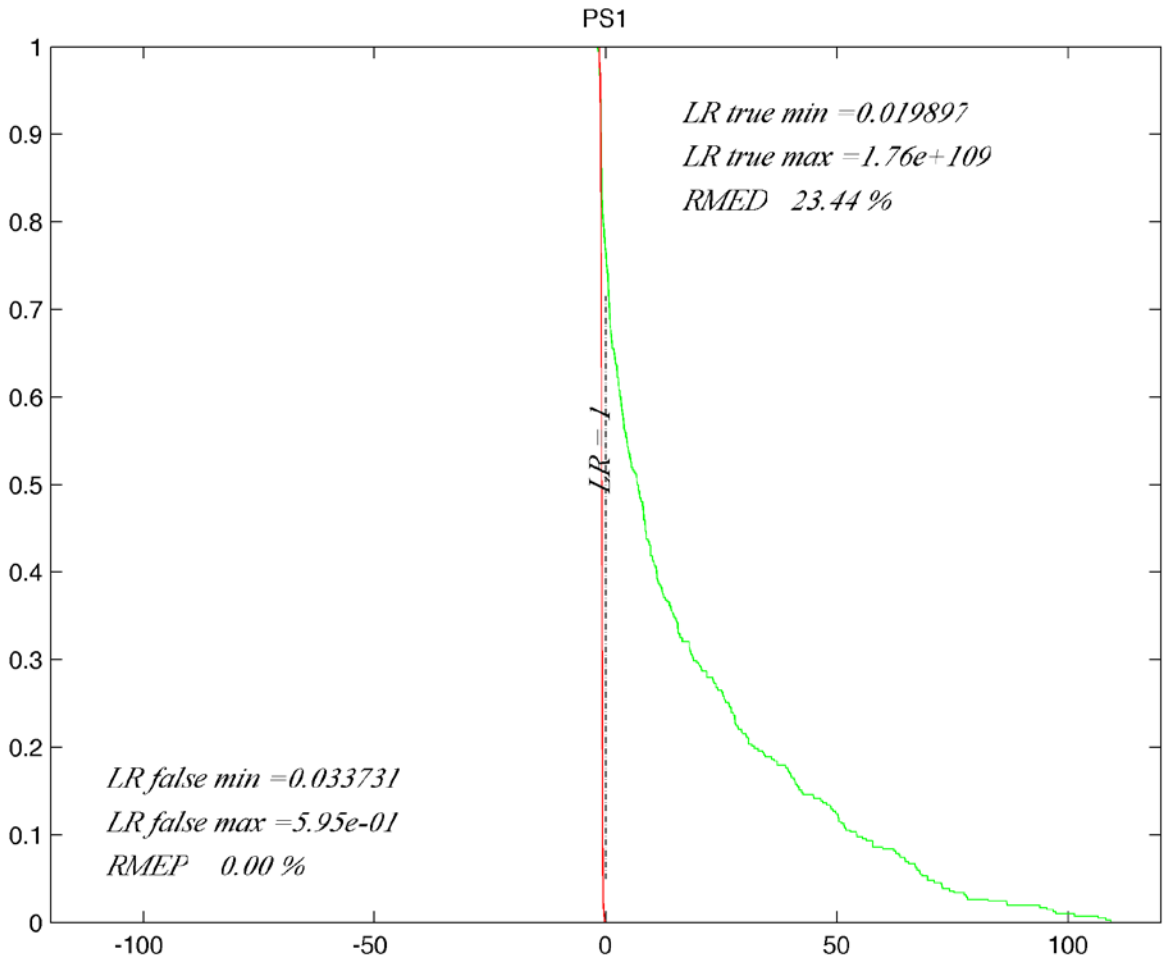
LR computation



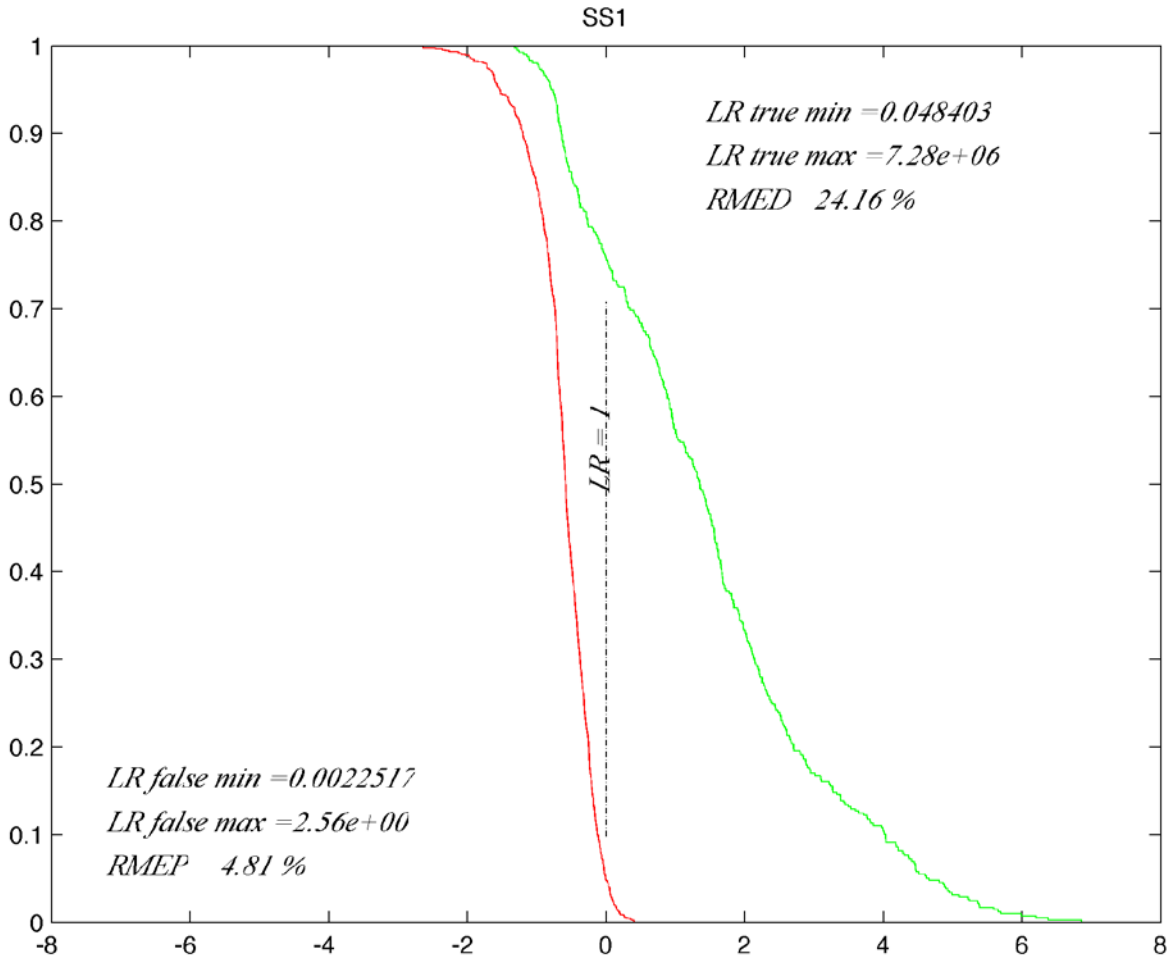
Results


RECIEVER-OPERATING CHARACTERISTICS (ROC) CURVE__seuil 3
TRUE POSITIVE RATIO
FALSE POSITIVE RATIO
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
PS3:0.87
SS3:0.877

Results


PS1
LR true min =0.019897
LR true max =1.76e+109
RMED 23.44 %
LR = 1
LR false min =0.033731
LR false max =5.95e-01
RMEP 0.00 %
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-100
-50
0
50
100

Results

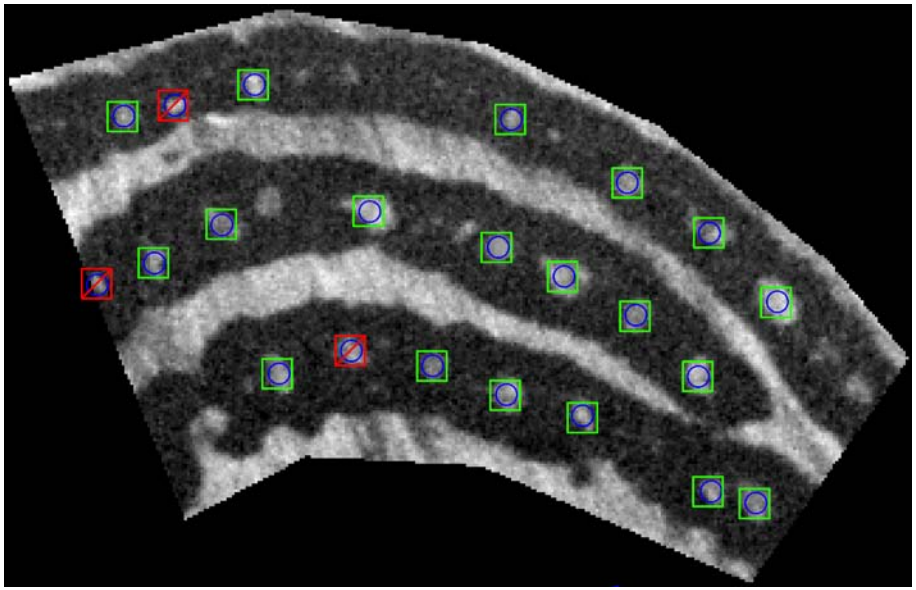

SS1
LR true min =0.048403
LR true max =7.28e+06
RMED 24.16 %
LR = 1
LR false min =0.0022517
LR false max =2.56e+00
RMEP 4.81 %
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-8
-6
-4
-2
0
2
4
6
8

Results

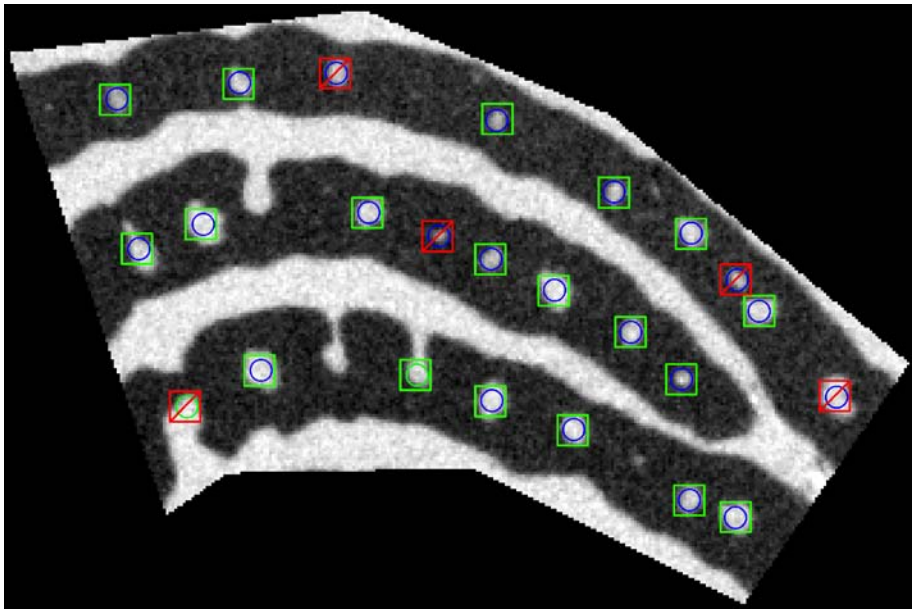
- When using the product score
  - The Rates of Misleading Evidence in favor of the Prosecution (RMEP) are extremely low (0 to 0.5%)
  - The magnitude of the LRs under H_p is difficult to interpret (up to 10^{300})
- When using the sum score
  - The RMEP are higher but still low (around 5%) and with small LRs
  - The magnitude of the LRs remains more reasonable
- For both scores rules, the Rates of Misleading Evidence in favor of the Defense (RMED) have values contained between 20% and 25%

Illustration

Mark



Reference



(Sum Score)

Conclusions

- The metric developed enables the interpretation of distances between pore configurations (when used in conjunction with a 2nd level feature)
- It could be integrated into a model taking into account information about the three levels of features