

Fingerprint Quality Measures, Lights Out Transactions and Multi-modal Searches

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with contributions of A. Bécue, B. Bonnaz, F. Puléo and Margaux Girod

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Fingerprint Quality To Assess fingerprint detection techniques

A. Bécue, B. Bonnaz & C. Champod



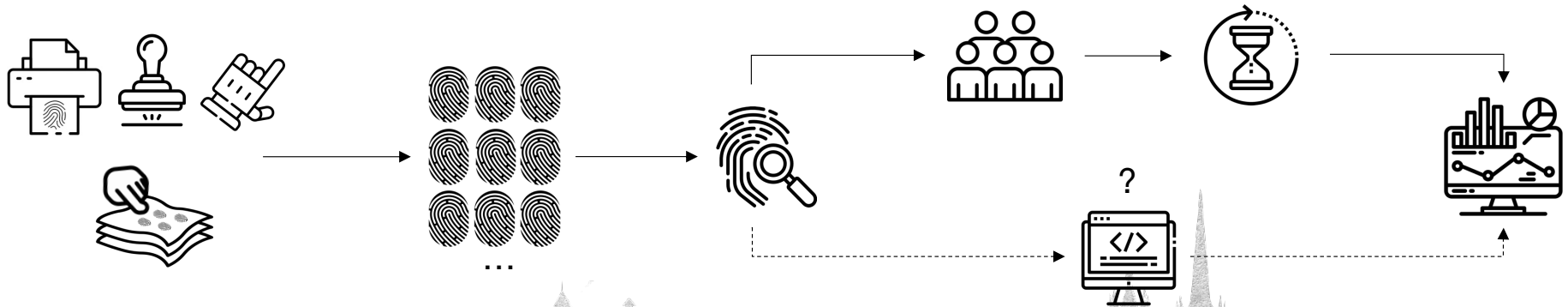
Context and main objective of the research

Context

- Development and optimization of (new) fingerprint detection techniques
 - Large sets of fingerprints required (IFRG guidelines, numerous donors, several substrates, ...)
 - Assessment of the processed fingerprints based on human examiners (time-consuming, subjective, various scales)

Main objective of the research

Investigate the application of algorithms used in the identification field to quickly and objectively assess large sets of fingerprints, and provide decision support (reagent performance, reproducibility, ...)



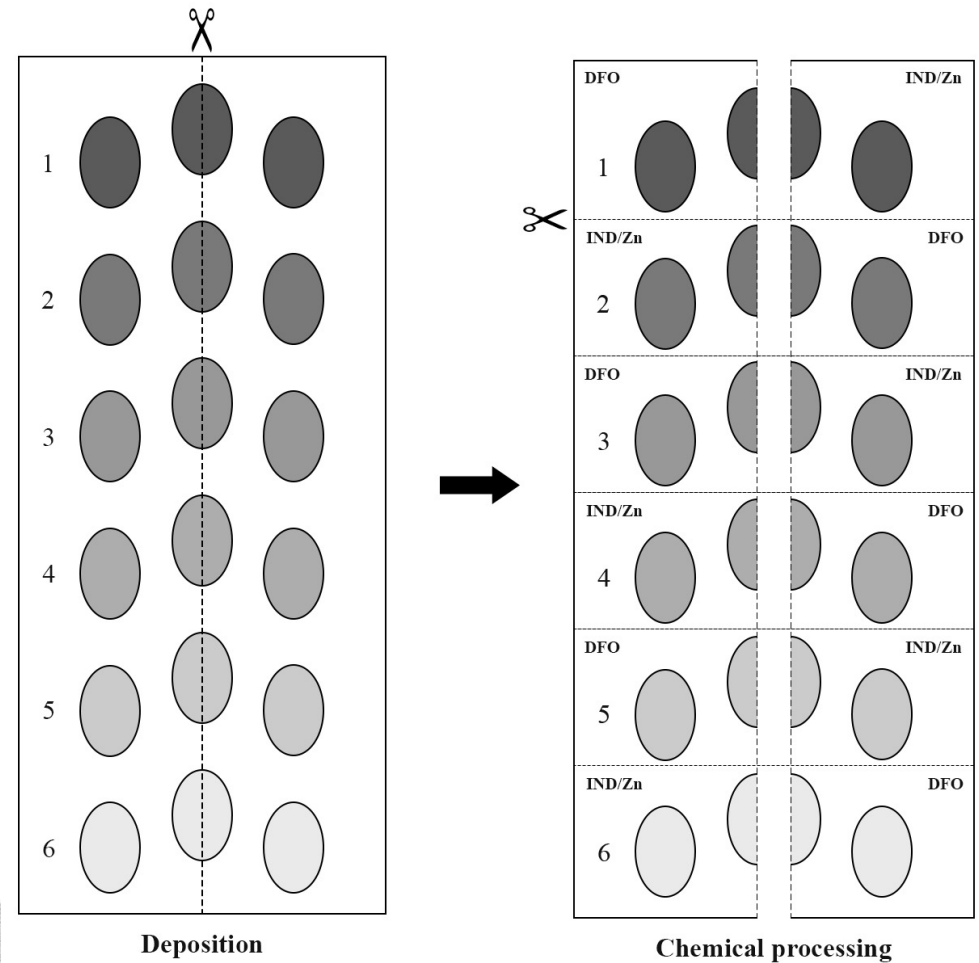
Application to «IND/Zn vs DFO» – Methodology

Experiment

- 10 donors
- 5 porous substrates
- 3 fingers (index, middle, ring)
- 6 depletions
- 3 aging times (1 day, 1 week, 1 month)

⇒ 2700 natural fingerprints
(1800 full marks + 1800 half marks)

⇒ **Consensus** among laboratories and countries,
in favour of IND/Zn



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Application to «IND/Zn vs DFO» – Methodology

Quality assessment by two automated algorithms

- LQM (Noblis/FBI) – Latent Quality Metric

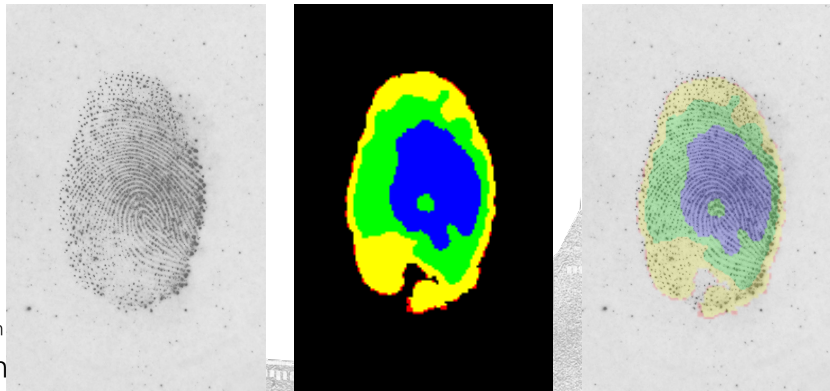
OQ (Overall Quality) – indication of the predicted probability of a successful AFIS search

Score range 0 – 100

OC (Overall Clarity) – measure of the level of confidence in the presence or absence of friction ridge detail in the impression

Score range 0 – 100

Clarity maps



Meaning of the clarity map colours ¹

Black	Background
Red	Debatable ridge flow
Yellow	Definitive ridge flow, debatable minutiae
Green	Definitive minutiae, debatable ridge edges
Blue	Definitive ridge edges, debatable pores



Application to «IND/Zn vs DFO» – Methodology

- ILFQM (IDEMIA) – Improved Latent Fingerprint Quality Metrics

MAQ (Mark AFIS Quality) – indication of the extent to which the fingerprint is of sufficiently good quality for a search in AFIS

No_Value (no rank)

Low_MAQ (rank 10-100)

Medium_MAQ (rank 2-10)

High_MAQ (rank 1)

MCQ (Mark Comparison Quality) – indicates how easy it is for an expert to determine the value of a fingerprint for identification/exclusion purposes

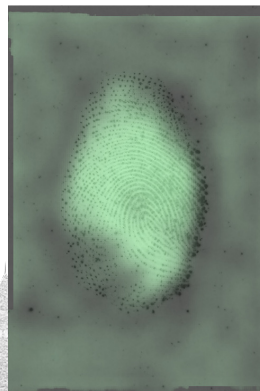
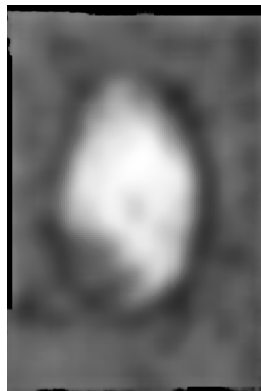
No_Value

Low_MCQ

Medium_MCQ

High_MCQ

Clarity maps



Meaning of the clarity map greyscale level



Clarity level

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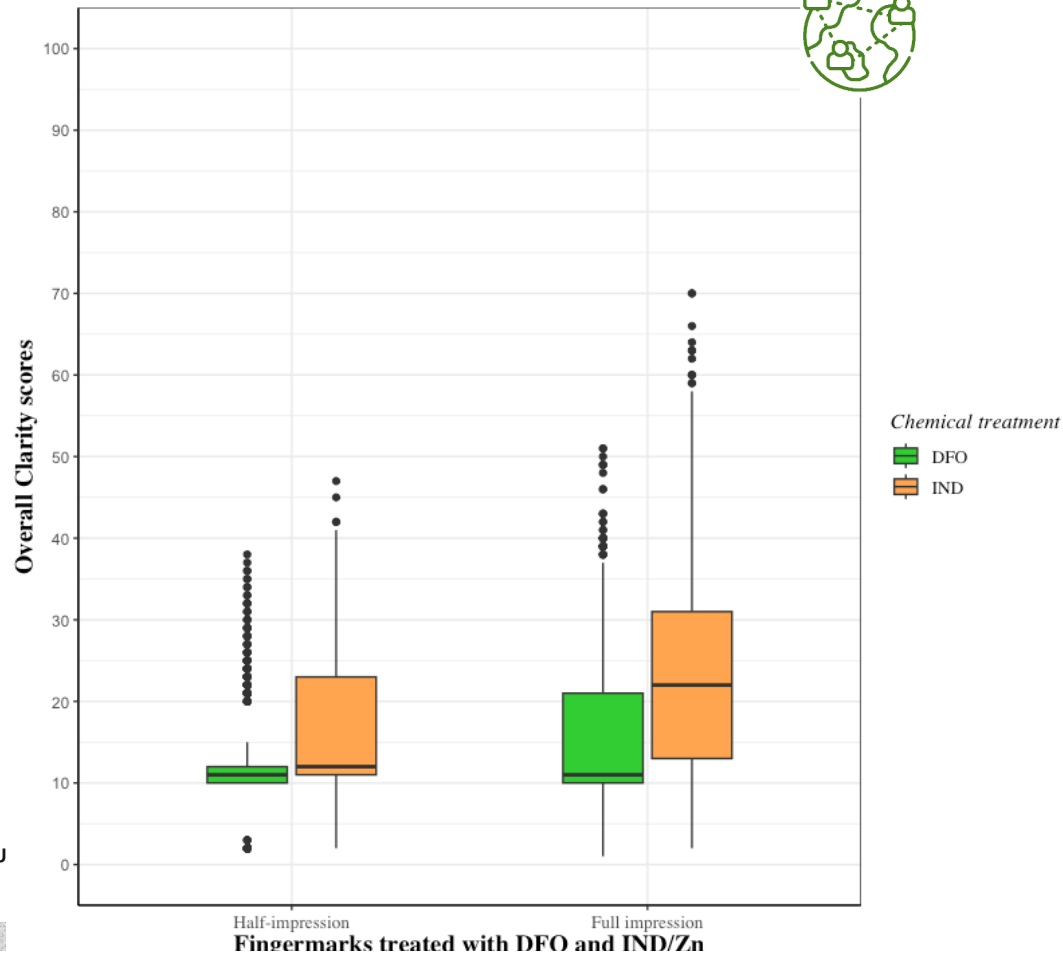
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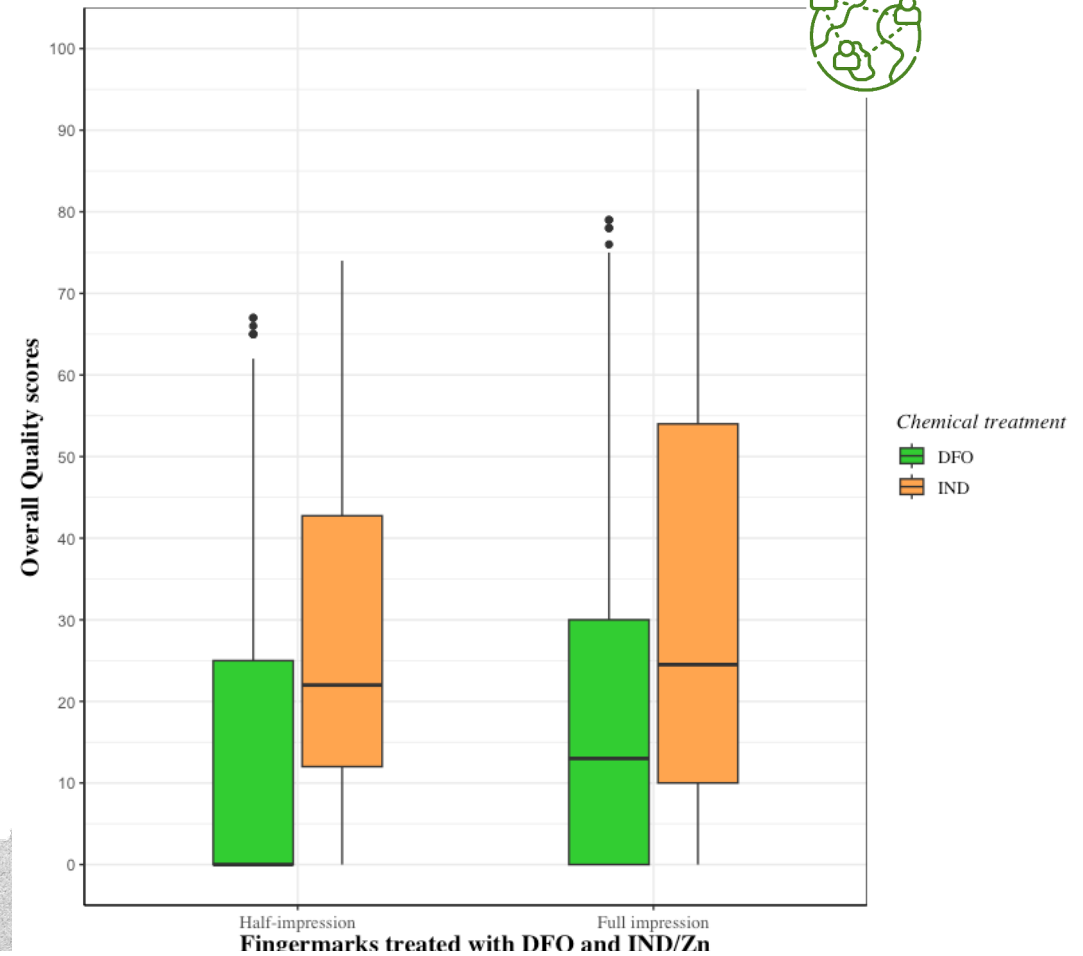


Application to «IND/Zn vs DFO» – Results

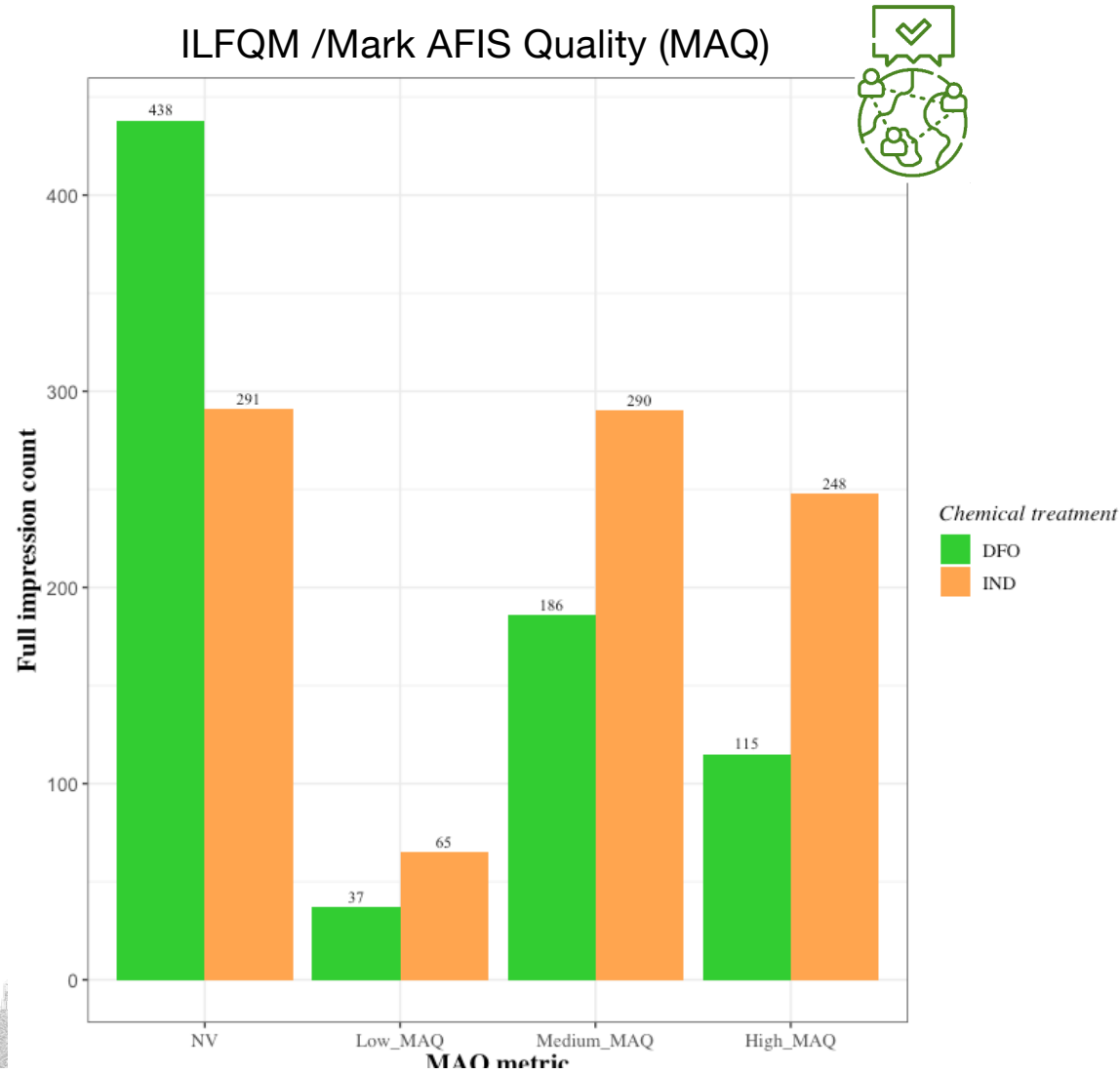
LQM /Overall Clarity (OC) metrics



LQM /Overall Quality (OQ) metrics



Application to «IND/Zn vs DFO» – Results



Use of quality assessment algorithms for detection purposes

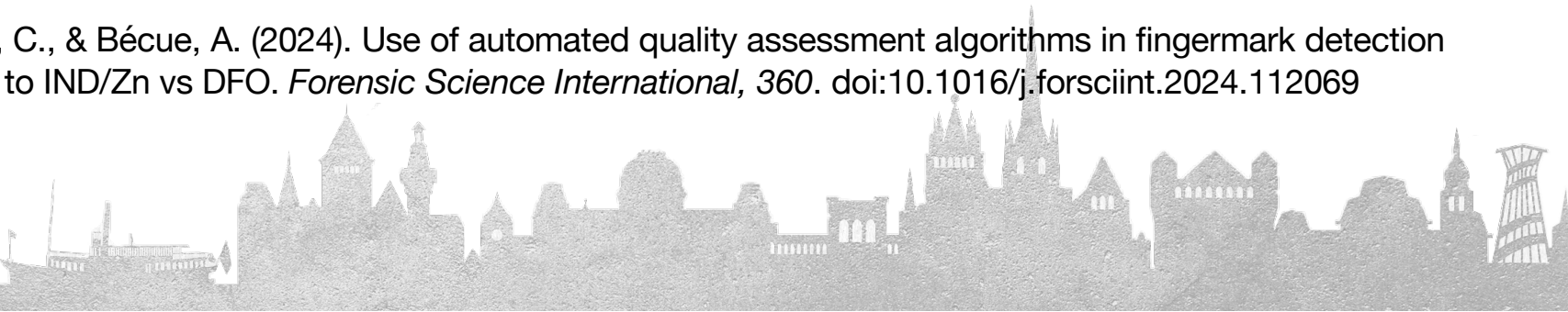
- The use of automated algorithm is a time-saving approach
(LQM ~1 s/img; ILFQM ~6 s/img; using a portable computer)
- Large sets of fingerprints can be processed at once
(human experts: limit to the number of marks provided to keep the task doable/reasonable)
- Several metrics can be provided per mark
- Subjectivity and need for several assessors are avoided
(the same set of fingerprints will provide the same scores)

Bonnaz, B., Champod, C., & Bécue, A. (2024). Use of automated quality assessment algorithms in fingerprint detection research – Application to IND/Zn vs DFO. *Forensic Science International*, 360. doi:10.1016/j.forsciint.2024.112069

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Lights Out Transactions with Fingermarks

F. Puléo & C. Champod



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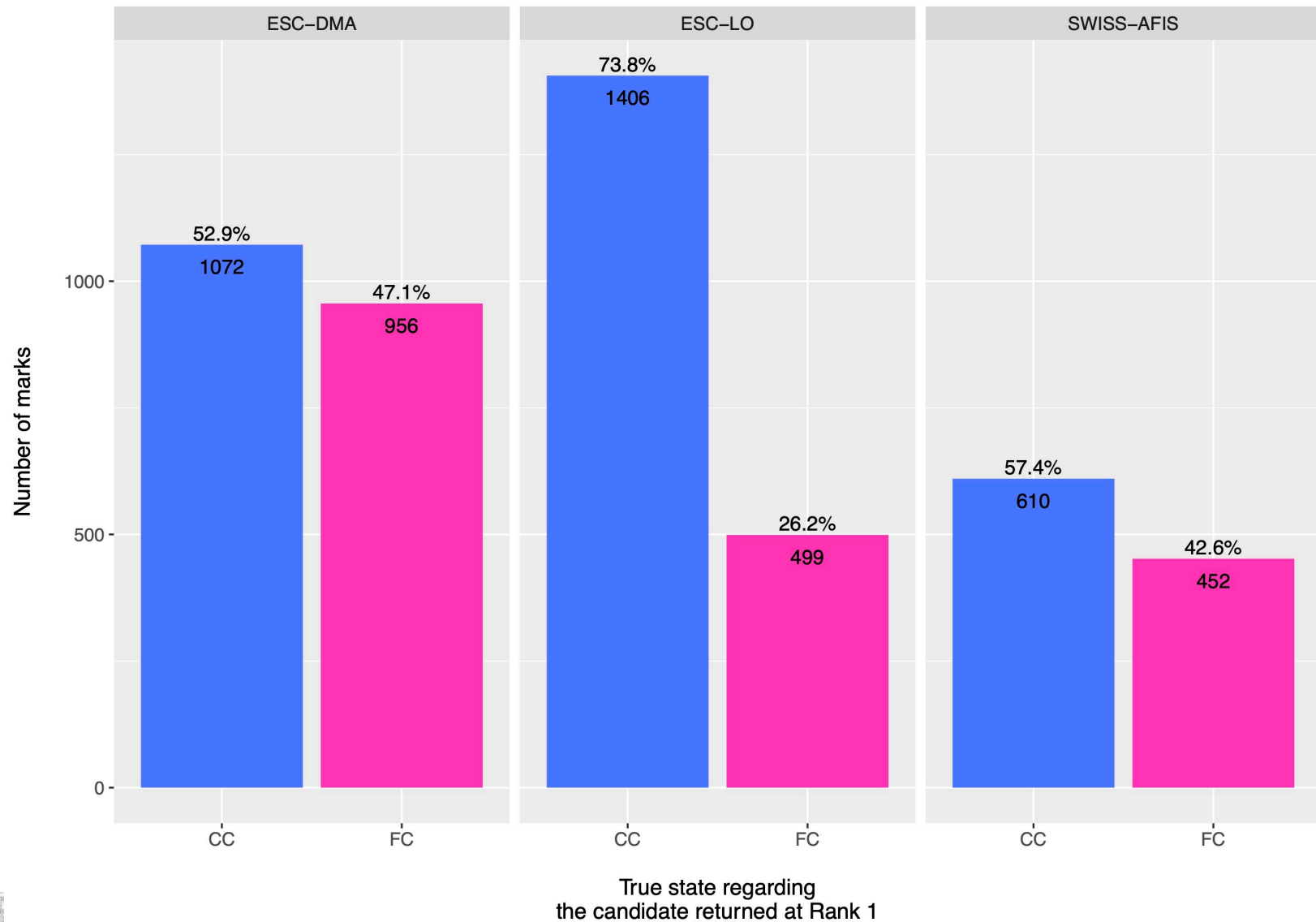


Lights-Out transactions

CC : correct
correspondance
@rank1

FC: false
correspondance
@rank1

Three different AFIS
systems (2005,
2011, 2016 with
different
datasets)



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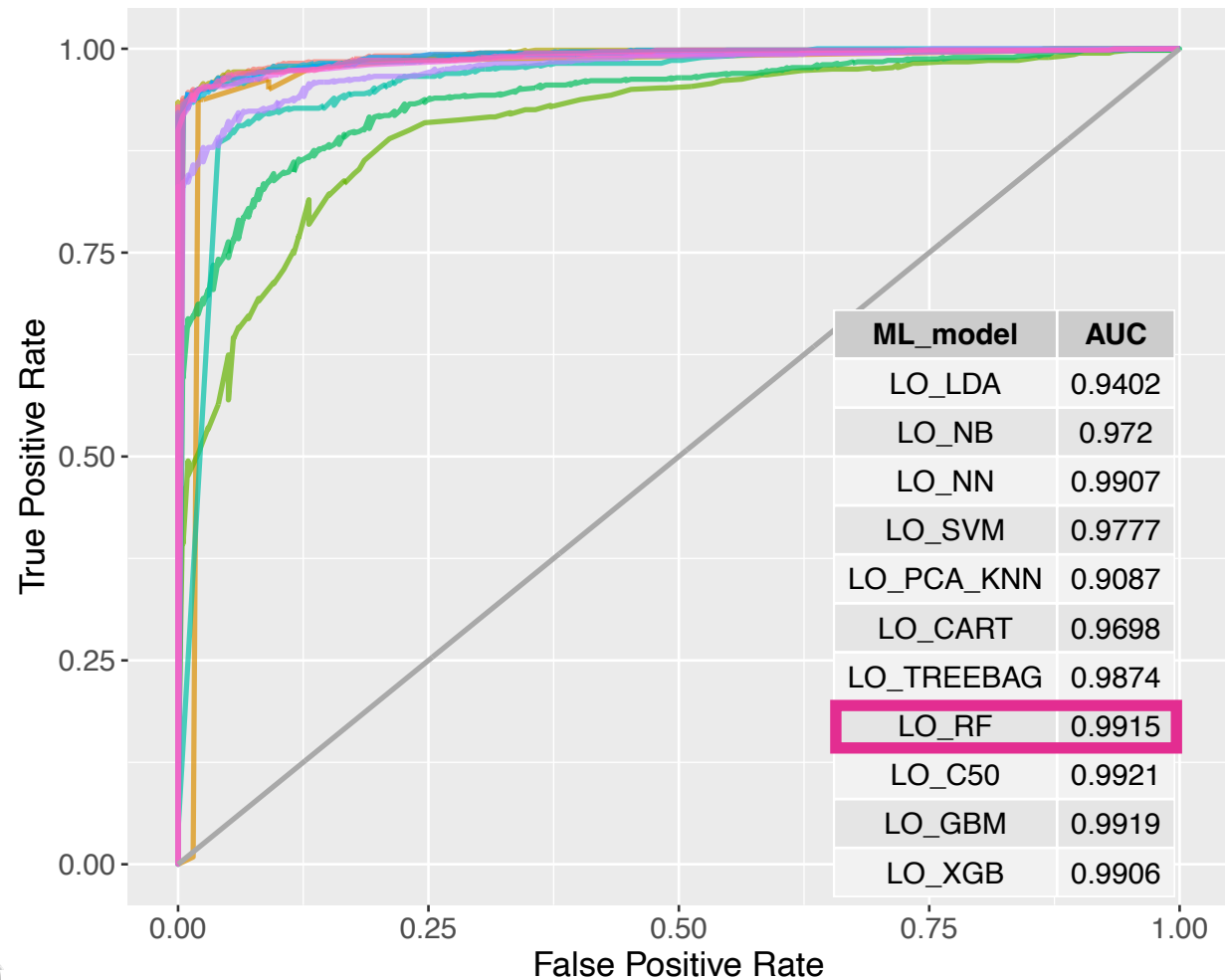
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Predicting rank@1 as CC

- Predictors

- Score rank@1
- Difference score rank@1 - rank@2
- # minutiae auto-encoded
- Internal quality measures (within AFIS)
- External quality measures (LFIQ1, LFIQ2, LQM, ILFQM, ESLR)

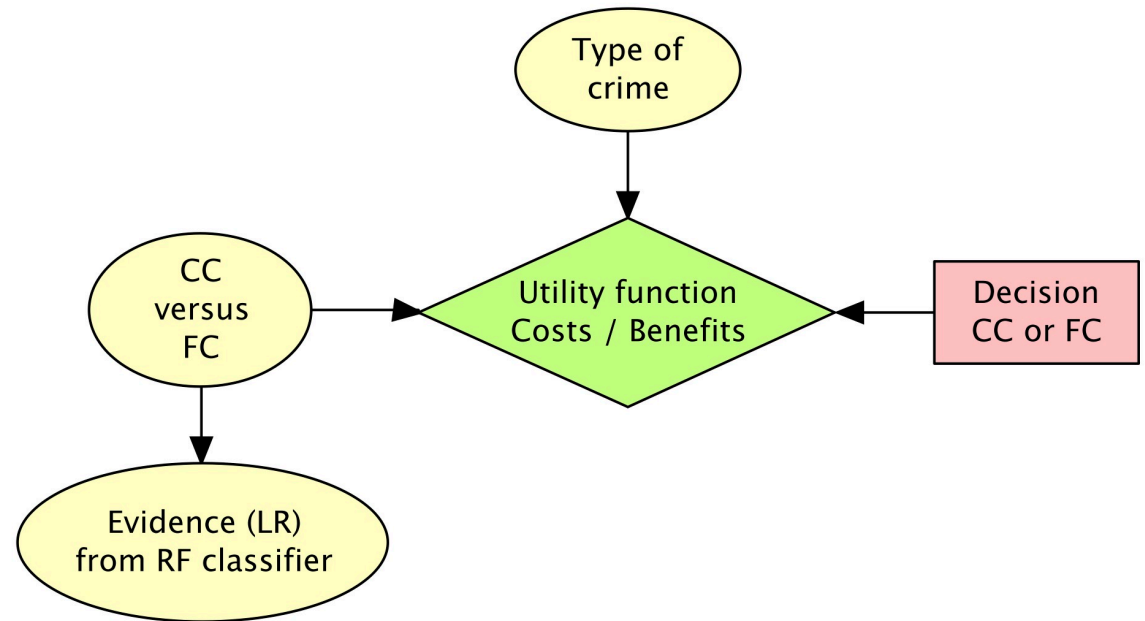


Setting the decision thresholds

Trained classifier (Random Forest)
to decide if the candidate @rank1
is the correct source

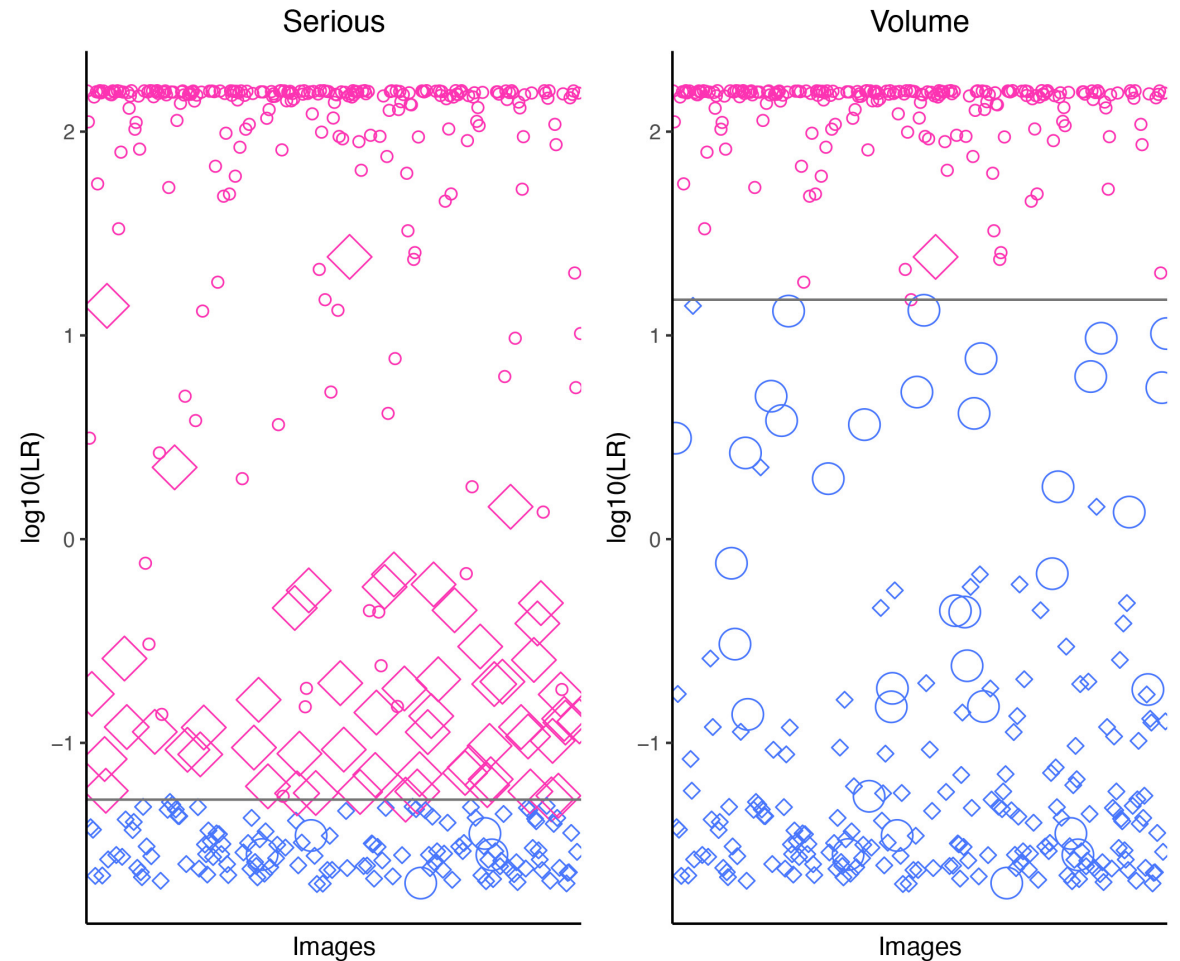
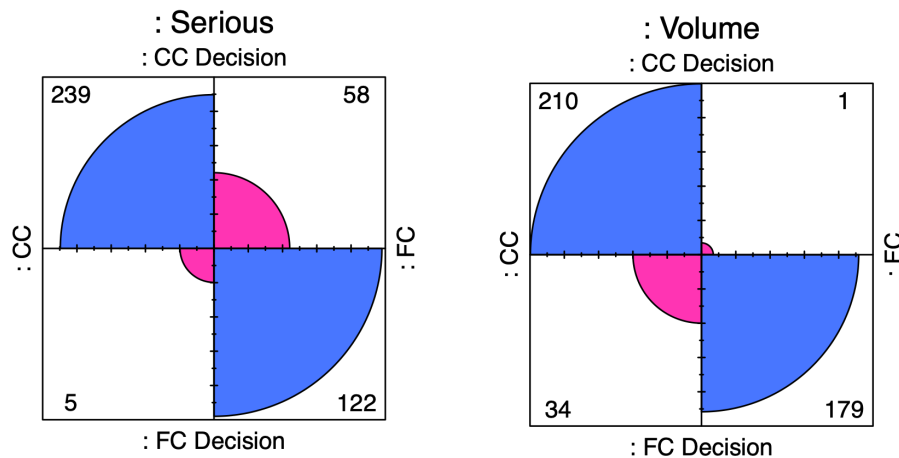
Calibrated to return a LR
expressing the degree of support in
favour of CC versus FC

Optimized decision threshold
based on a utility function
of the type of crime



Lights-Out transactions

Function of the LR and of the type of crime, we will have more or less wrong leads and missed leads



Decision ● CC Decision ● FC Decision TrueState ○ CC ◇ FC

Investigative leads

Leads are not IDs

In any list larger than one, you have a least one false lead

Error rates needs to be monitored and properly communicated



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Multi-biometric Searches

M. Girod & C. Champod



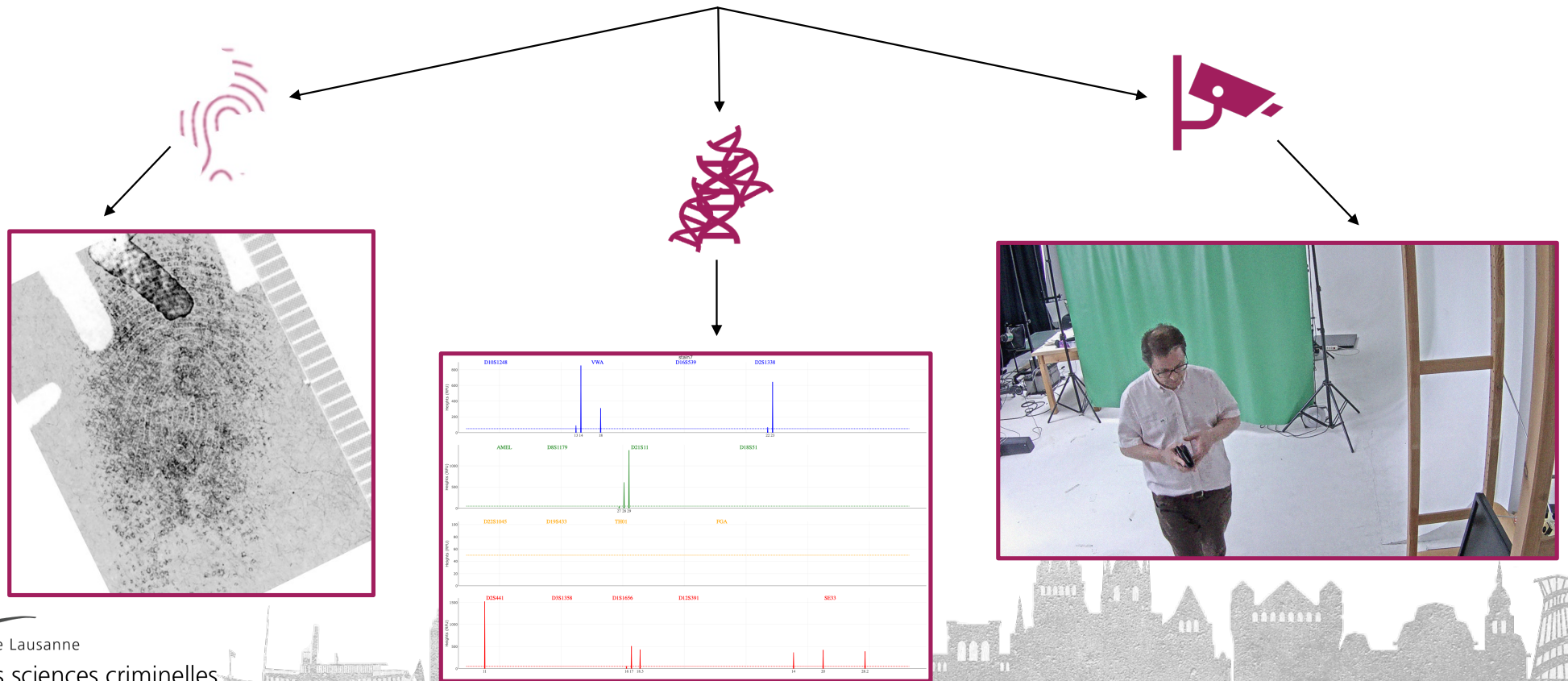
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Proof of concept

Incident under investigation



Data – DNA

Create forensic cases combining DNA / Fingerprints / Faces



- ESC reference dataset
(100 000 FedPol + 70 000 GE)

- Ground truth data:
Marks/Reference
based on Flore Puléo's PhD
(about 2000)



- Synthetic background DNA
profiles generated with
EuroForMix (200 000 individuals
to match the Swiss national DNA
DB)
- Traces and references profiles
generated with EuroForMix



- Police Mugshot database
VD (35000 individuals)
- Traces/References
PhD of Maëlig Jacquet's
PhD (about 1000)

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Quality measures and matching systems



➤ Quality : ILFQM

➤ Comparaison : MBSS
(v7.1)



➤ Quality : STRmix (ESLR)

➤ Comparaison : DBLR (v1.4)



➤ Quality : OFIQ

➤ Comparaison : MBSS
(v7.1)



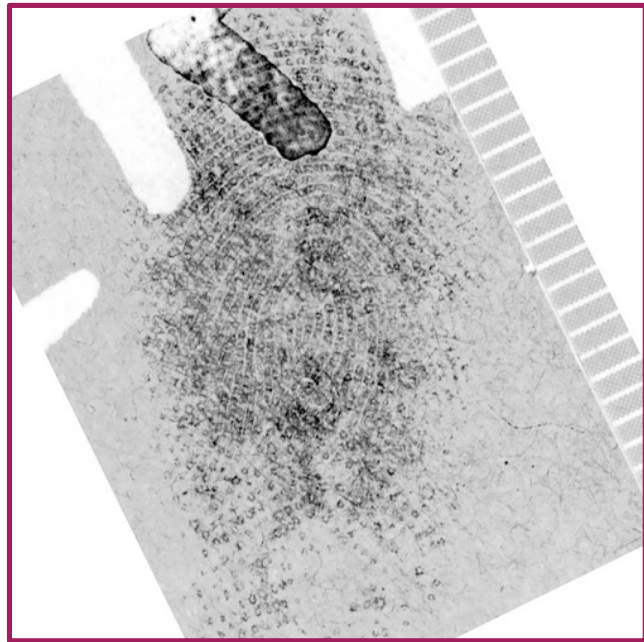
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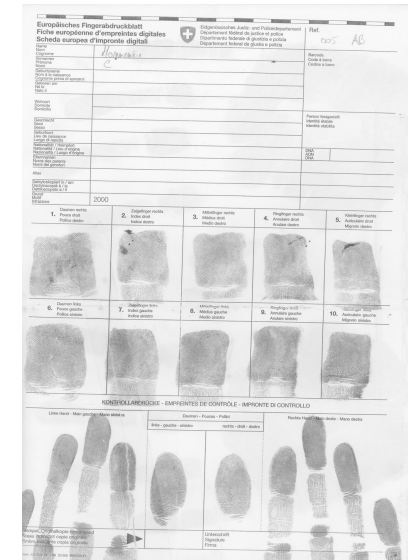
Fingermark



	ID	Score
1	ID068919	1764
2	ID106371	1437
3	ID069482	1382
4	ID086864	1340
5	ID082142	1339
6	ID042880	1329
7	ID065275	1255
8	ID054159	1246
9	ID124379	1117
10	ID038950	1099
11	ID111617	1076
12	ID042023	1071
13	ID103205	1070
14	ID080651	1055
15	ID028446	1043
16	ID057577	1038
17	ID006175	1023
18	ID007148	1018
19	ID097718	1008
20	ID031309	983

Quality measure

score	rank_estimation	class	MAQ
-0.178	Rank >100	1	NV



Person of
interest

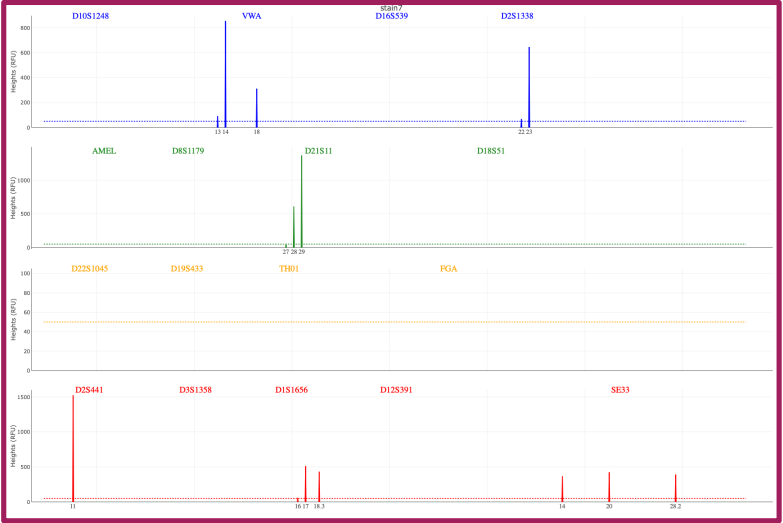
Rank : 29
Score :
874

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DNA



Quality measure

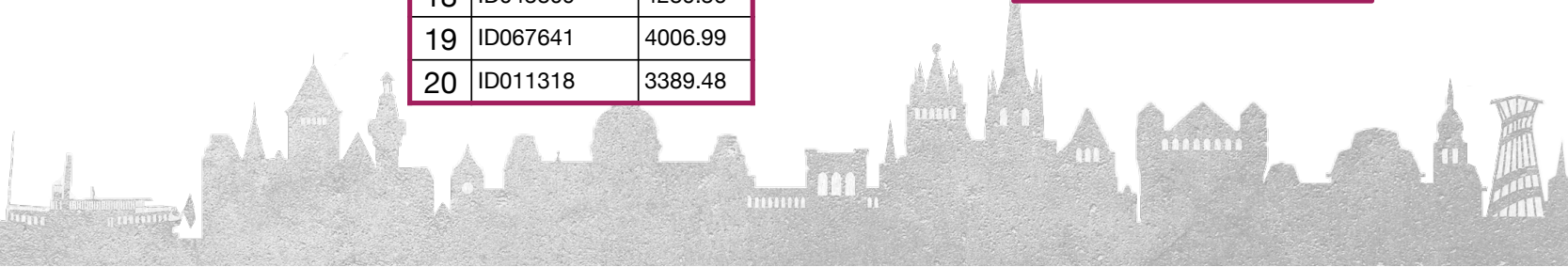
2 contributeurs
6 loci

	ID	LR
1	ID129049	42036.65
2	ID171025	21607.88
3	ID011578	19428.25
4	ID006758	17567.28
5	ID004975	13716.85
6	ID149463	13161.80
7	ID193890	10418.77
8	ID110768	10057.12
9	ID152798	9621.32
10	ID040218	9057.19
11	ID140324	8326.11
12	ID101127	7393.21
13	ID126687	6635.39
14	ID024547	6347.68
15	ID117711	4843.65
16	ID084385	4435.60
17	ID170018	4435.60
18	ID043809	4289.36
19	ID067641	4006.99
20	ID011318	3389.48

Marker	Allele1	Allele2
D1S1656	17	15
D2S1338	23	20
D2S441	11	15
D3S1358	15	16
D8S1179	15	13
D10S1248	14	14
D12S391	19	25
D16S539	12	11
D18S51	15	13
D19S433	17.2	14
D21S11	29	28
D22S1045	17	15
FGA	19	21
SE33	14	20
TH01	6	9.3
VWA	14	14

Person of
interest

Rank : 46
LR : 1151



Face



Quality measure

No Value

	ID	Score
1	ID002397	1424
2	ID018919	1269
3	ID001301	1232
4	ID001168	1176
5	ID009860	1162
6	ID013152	1120
7	ID006250	1029
8	ID031147	1013
9	ID014001	1007
10	ID022965	983
11	ID032636	982
12	ID000770	959
13	ID025757	946
14	ID028280	933
15	ID028318	930
16	ID003257	918
17	ID002971	906
18	ID022394	896
19	ID028686	886
20	ID026439	867



Person of interest

Rang : 62
Score :
711

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Very basic fusion mechanism



	ID	Score
1	ID068919	1764
2	ID106371	1437
3	ID069482	1382
4	ID086864	1340
5	ID082142	1339
6	ID042880	1329
7	ID065275	1255
8	ID054159	1246
9	ID124379	1117
10	ID038950	1099
11	ID111617	1076
12	ID042023	1071
13	ID103205	1070
14	ID080651	1055
15	ID028446	1043
16	ID057577	1038
17	ID006175	1023
18	ID007148	1018
19	ID097718	1008
20	ID031309	983

Rang : 29
Score : 874



	ID	LR
1	ID129049	42036.65
2	ID171025	21607.88
3	ID011578	19428.25
4	ID006758	17567.28
5	ID004975	13716.85
6	ID149463	13161.80
7	ID193890	10418.77
8	ID110768	10057.12
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16	ID084385	4435.60
17	ID170018	4435.60
18	ID043809	4289.36
19	ID067641	4006.99
20	ID011318	3389.48

Rang : 46
LR : 1151



	ID	Score
1	ID002397	1424
2	ID018919	1269
3	ID001301	1232
4	ID001168	1176
5	ID009860	1162
6	ID013152	1120
7	ID006250	1029
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10	ID022965	983
11	ID032636	982
12	ID000770	959
13	ID025757	946
14	ID028280	933
15	ID028318	930
16	ID003257	918
17	ID002971	906
18	ID022394	896
19	ID028686	886
20	ID026439	867

Rang : 62
Score : 711



Rang : 1
Score :
253,69

Fusion with normalisation
and weighted sum

	ID	Score
1	POI	253,89
2	ID002397	100,00
3	ID068919	100,00
4	ID129049	100,00
5	ID018919	85,31
6	ID001301	81,80
7	ID106371	81,46
8	ID069482	78,34
9	ID001168	76,49
10	ID086864	75,96
11	ID082142	75,91
12	ID042880	75,34
13	ID009860	75,17
14	ID013152	71,18
15	ID065275	71,15
16	ID054159	70,63
17	ID124379	63,32
18	ID006250	62,56
19	ID038950	62,30
20	ID031147	61,04

Investigative leads

Each modality is insufficient to provide reasonable leads

Requires a thorough assessment of the assumption that the traces are linked a single person

But it will allow to develop leads with with a joint usage of current biometric systems



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Thank you for your kind attention !

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