ON THE FREQUENCY OF PATTERN TYPES AND MINUTIAE ON THE INTERDIGITAL AREA OF PALMPRINTS: TOWARD AUTOMATED DETECTION

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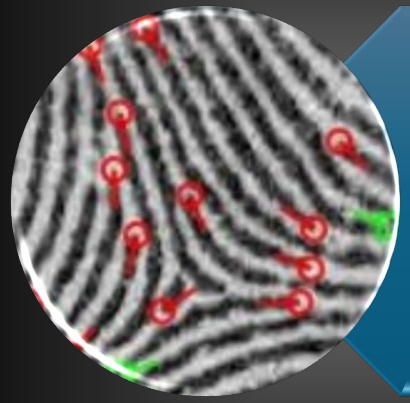
Overview

PART I

Interdigital frequencies of pattern types and their arrangements as a key to palm print identification



PART II

The relationship between the ridge patterning and the frequency of minutiae on the interdigital area of palmprints

PART III

Future work: Automated detection and frequency-based interpretation of palmprint features for friction ridge examinations

Why the interdigital area?

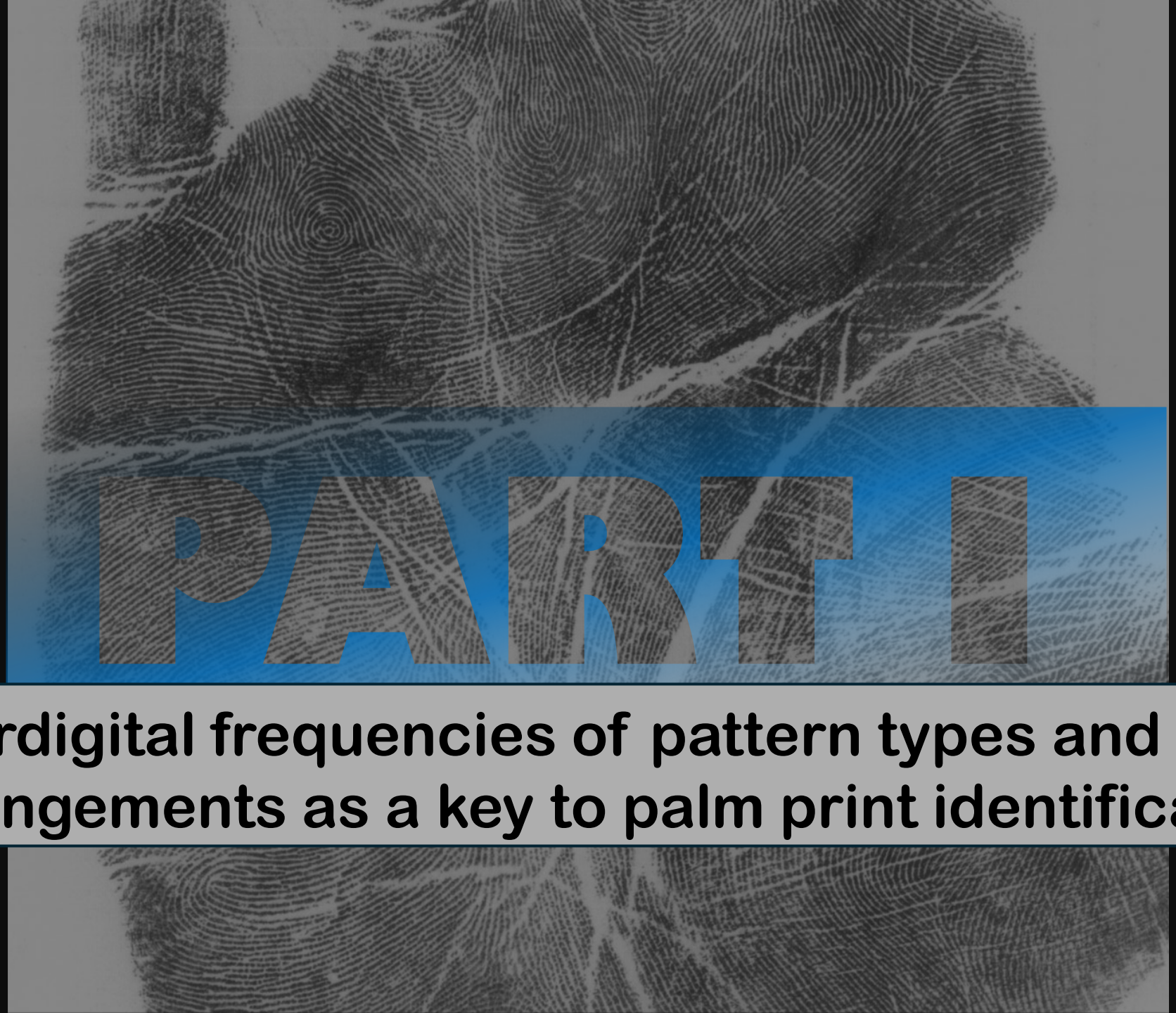
Deltas and cores:

- Number
- Type
- Location
- Arrangements

The most ridge flow characteristics

The most complex region

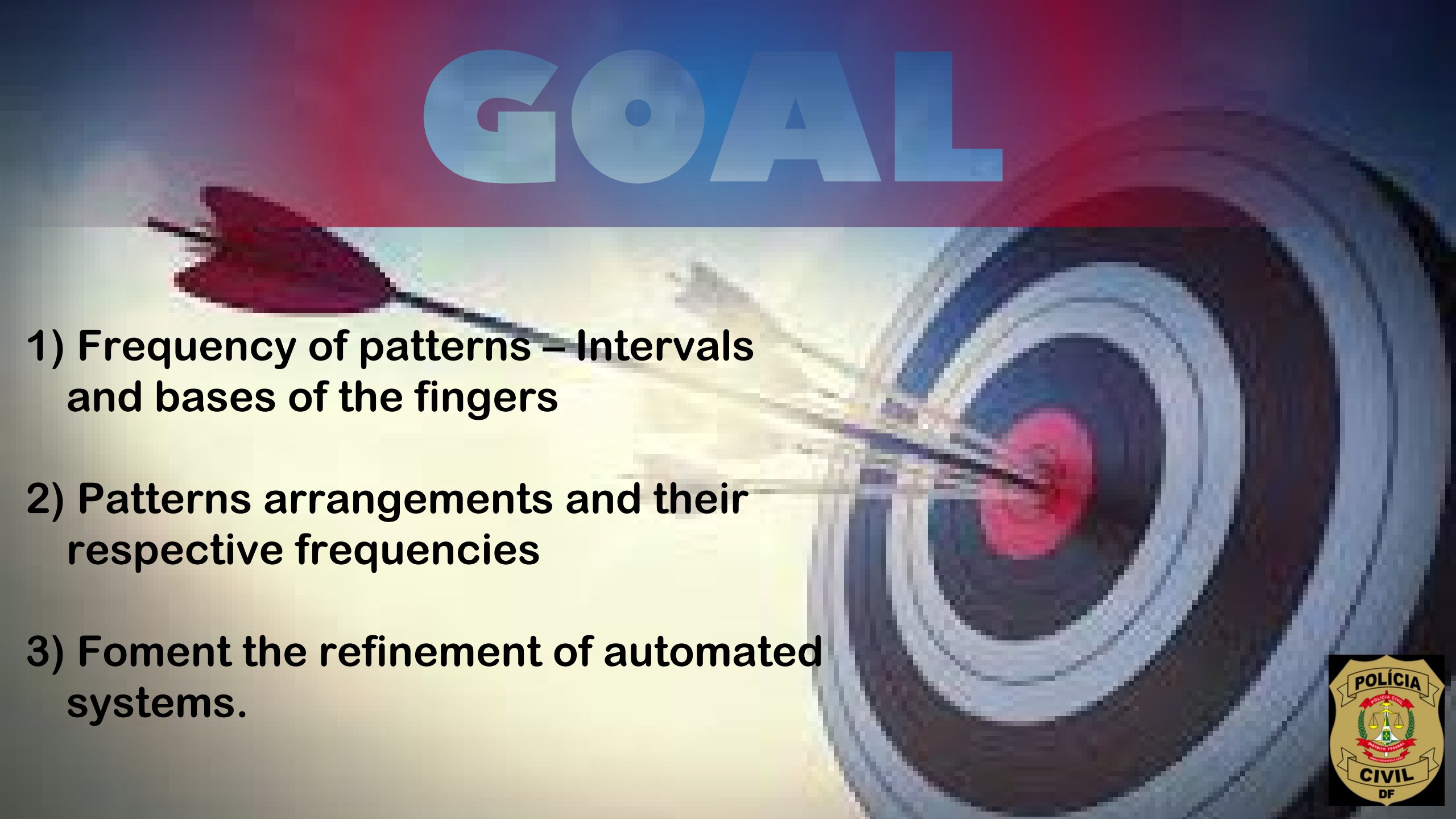
Where the greatest variation in crest flow occurs



PART I

Interdigital frequencies of pattern types and their arrangements as a key to palm print identification

GOAL



1) Frequency of patterns – Intervals and bases of the fingers

2) Patterns arrangements and their respective frequencies

3) Foment the refinement of automated systems.

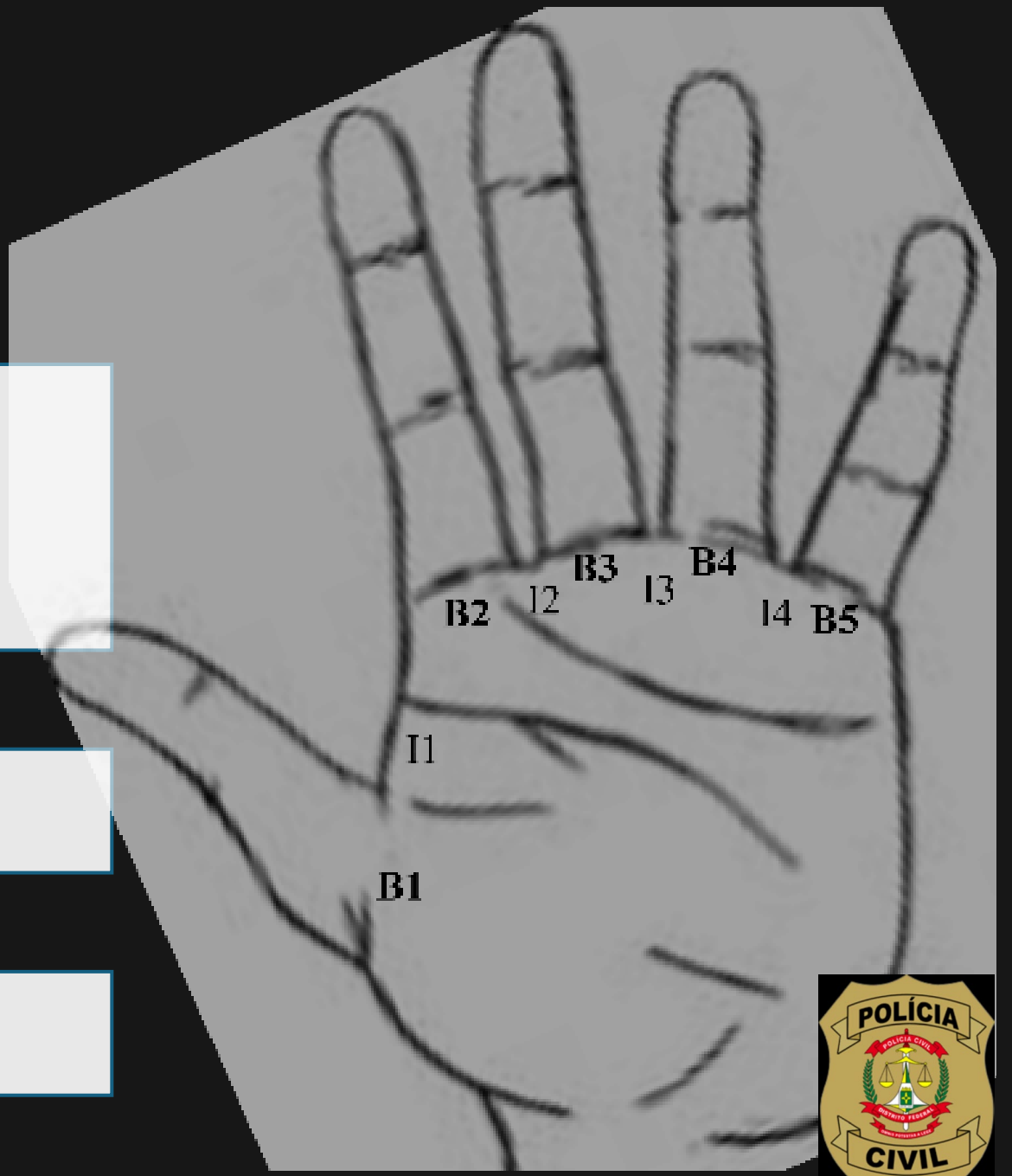
METHODOLOGY

4000 palmprints

- 2000 - right hand
- 2000 - left hand

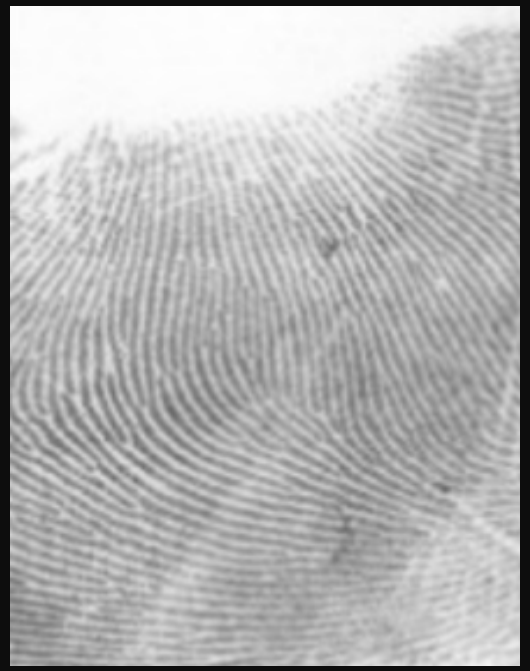
4 intervals (I1, I2, I3 e I4)

5 bases (B1, B2, B3, B4, e B5)



METHODOLOGY

Palmprint analysis
Patterns at the intervals



No pattern
(code 0)

Loop
(code 2)

Composite
(code 3)

Whorl
(code 4)

METHODOLOGY

Palmprint analysis
Patterns at the bases

Delta
(code 0)

Plain Arch
(code 1)

Tented Arch
(code 2)

Arrangements

on the intervals	I1 - I2 - I3 - I4
on the bases	B1 – B2 – B3 – B4 – B5
on intervals and bases in combination	B1 – I1 – B2 – I2 – B3 – I3 – B4 – I4 – B5

RESULTS
Pattern frequencies

Interval 1	Interval 2	Interval 3	Interval 4
All patterns No pattern (Code 0) is the prevalent (more than 94%)	No pattern (Code 0) – 95.6% Loop (Code 2) – 4.4%	All patterns No pattern (Code 0) is the prevalent – 67.67% Loop (Code 2) – 32.07% Composite (Code 3) – 0.03% Whorl (Code 4) – 0.22%	All patterns No pattern (Code 0) – 44.57% Loop (Code 2) – 52.08% Composite (Code 3) – 2.48% Whorl (Code 4) – 0.88% Right hand – 51.5% no pattern Left hand – 37.65% no pattern

Base 1	Base 2	Base 3	Base 4	Base 5
Plain arch – 97.72% Delta – 2.28%	Delta – 100%	Delta – 99.93% Tented arch – 0.07%	Delta – 73.45% Plain arch – 6.32% Tented arch – 20.23%	Delta – 99.8% Plain arch – 0.18% Tented arch – 0.03%

RESULTS

Arrangements on the intervals

33 arrangements observed

19 common to both hands

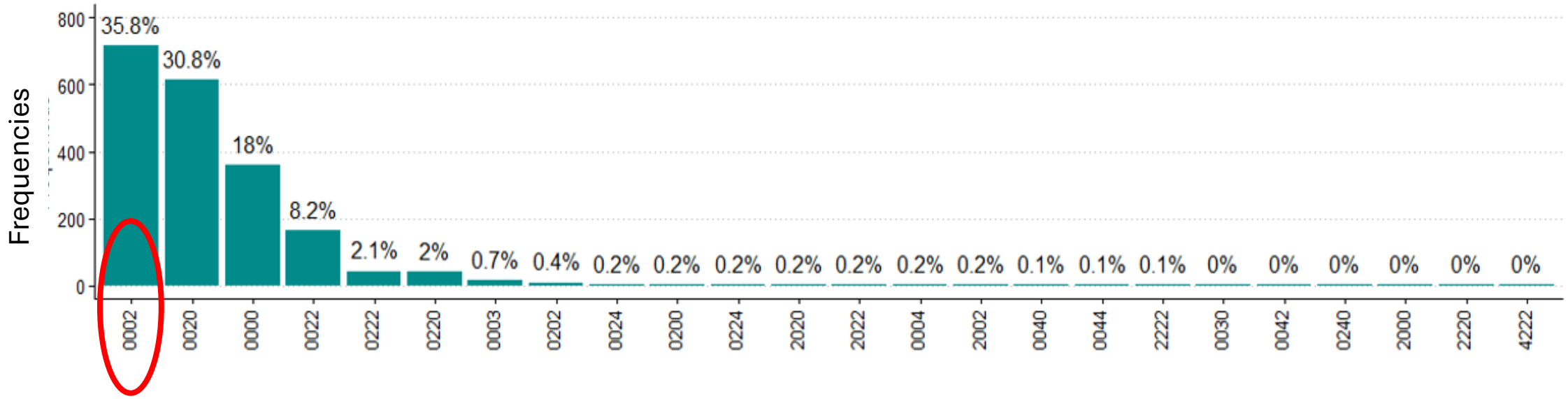
5 exclusively on the right hand

9 exclusively on the left hand

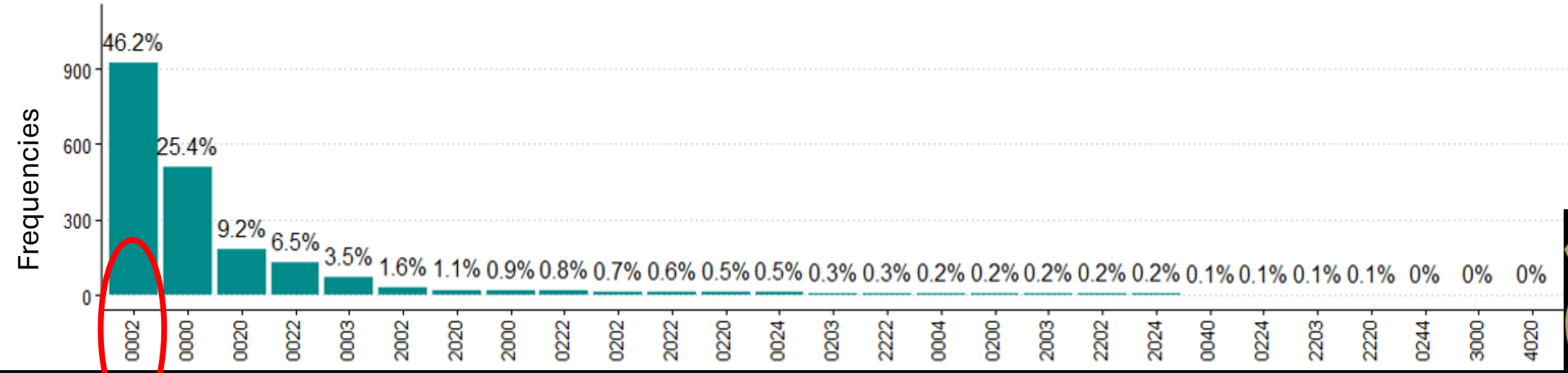
The frequency of exclusive arrangements is less than 0.3%

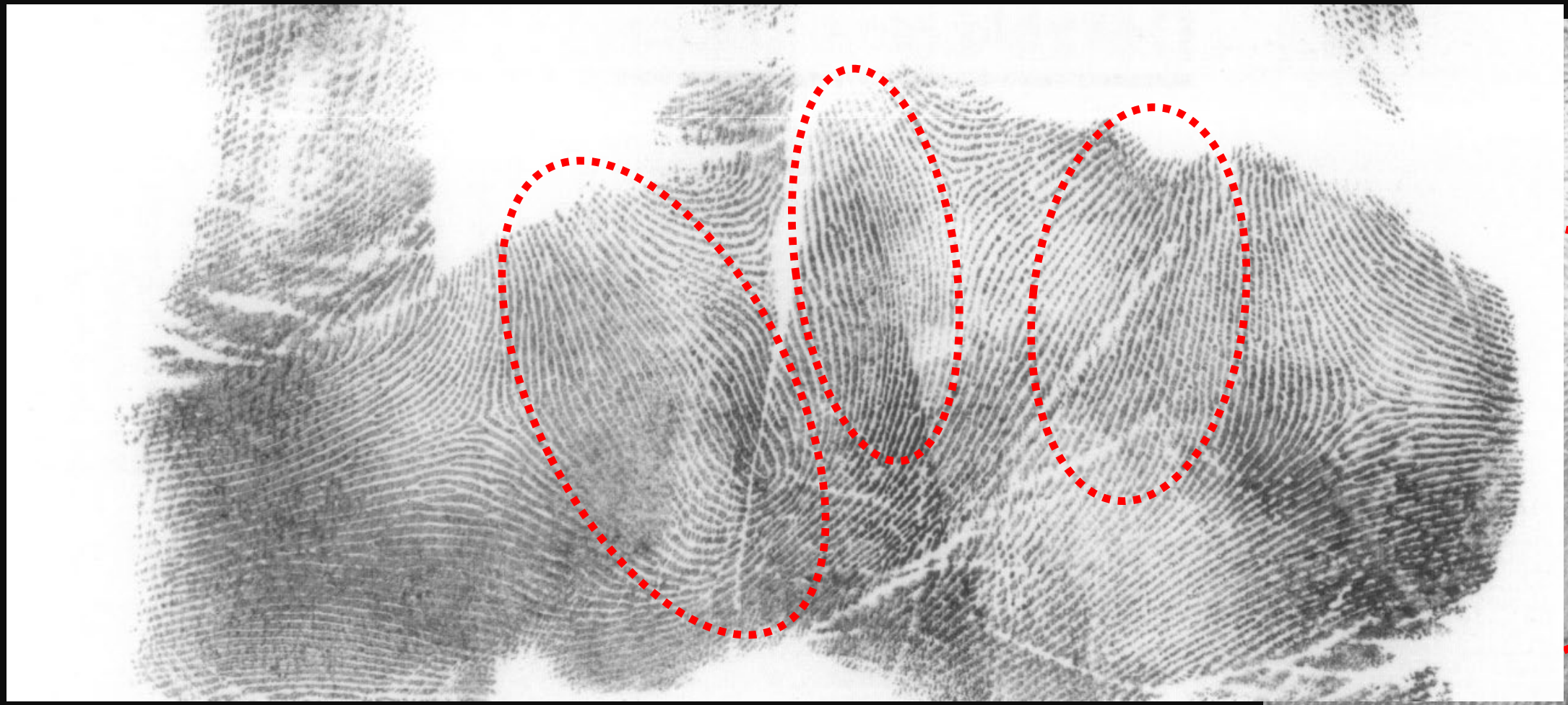
4222 1 (0.03%) 1 (0.05%) 0 (0%)

Right hand (N = 2000)



Left hand (N = 2000)





Most common arrangement on the intervals: 0-0-0-2

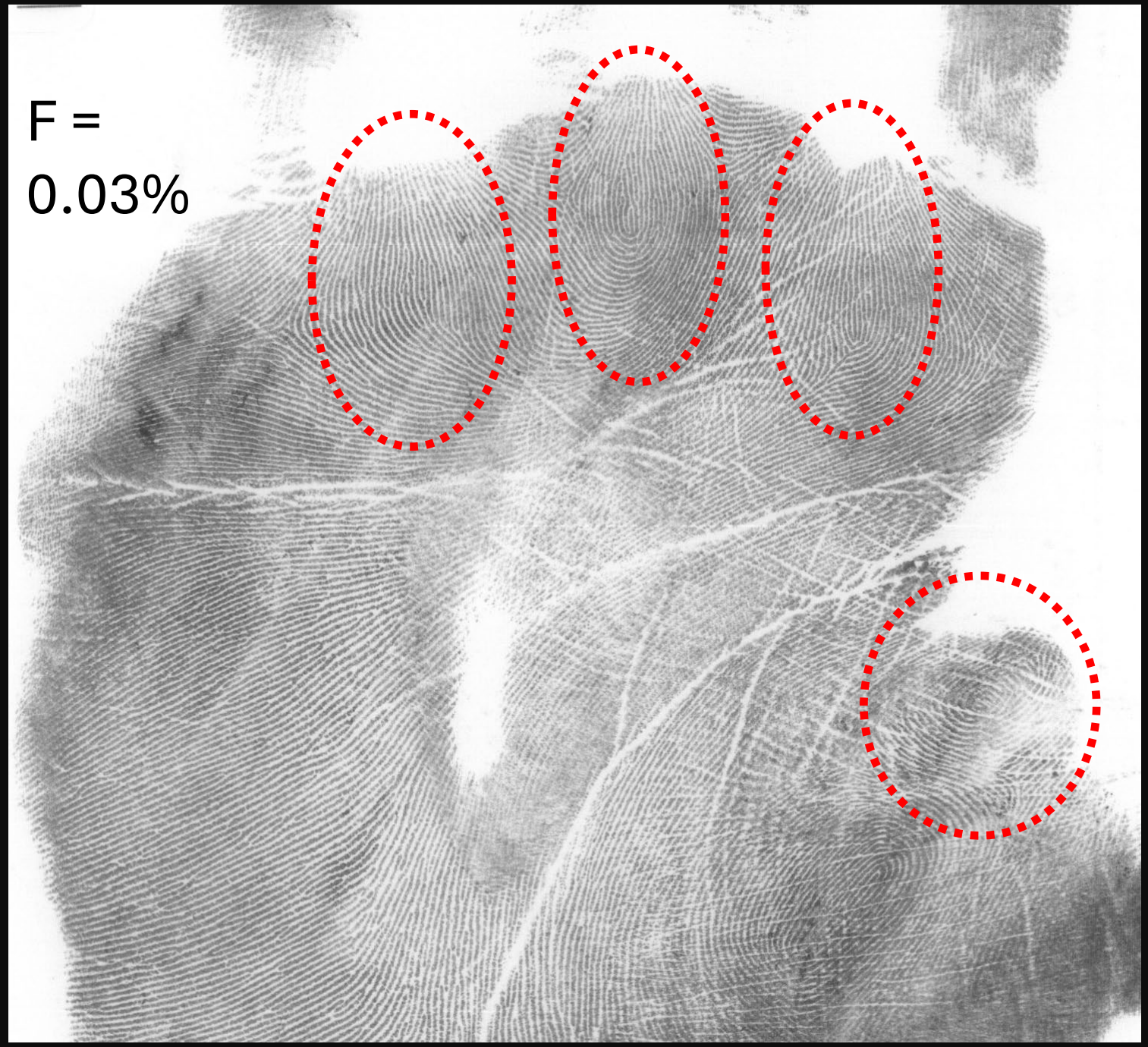
I1	I2	I3	I4
no pattern	– no pattern	– no patter	– loop

F =
0.1%

Rare arrangement that occurs in both hands: 0-0-4-0

I1 I2 I3 I4

No pattern – no pattern – whorl – no pattern



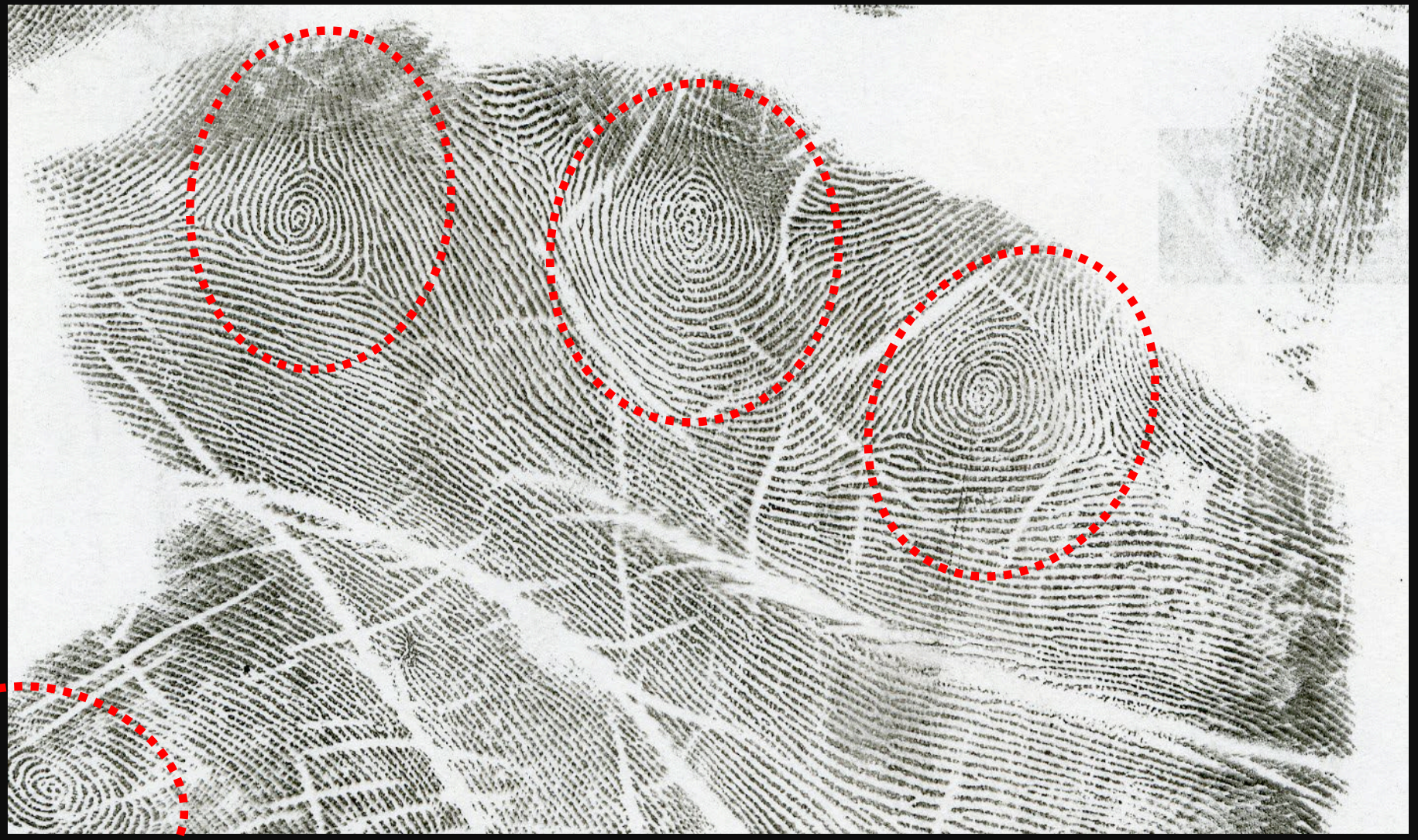
F =
0.03%

Arrangement 4-2-2-0

I1 I2 I3 I4

whorl – loop – loop – no patter

Would it be possible to see a palmprint with a whorl in all four intervals?



RESULTS

Arrangements on the bases

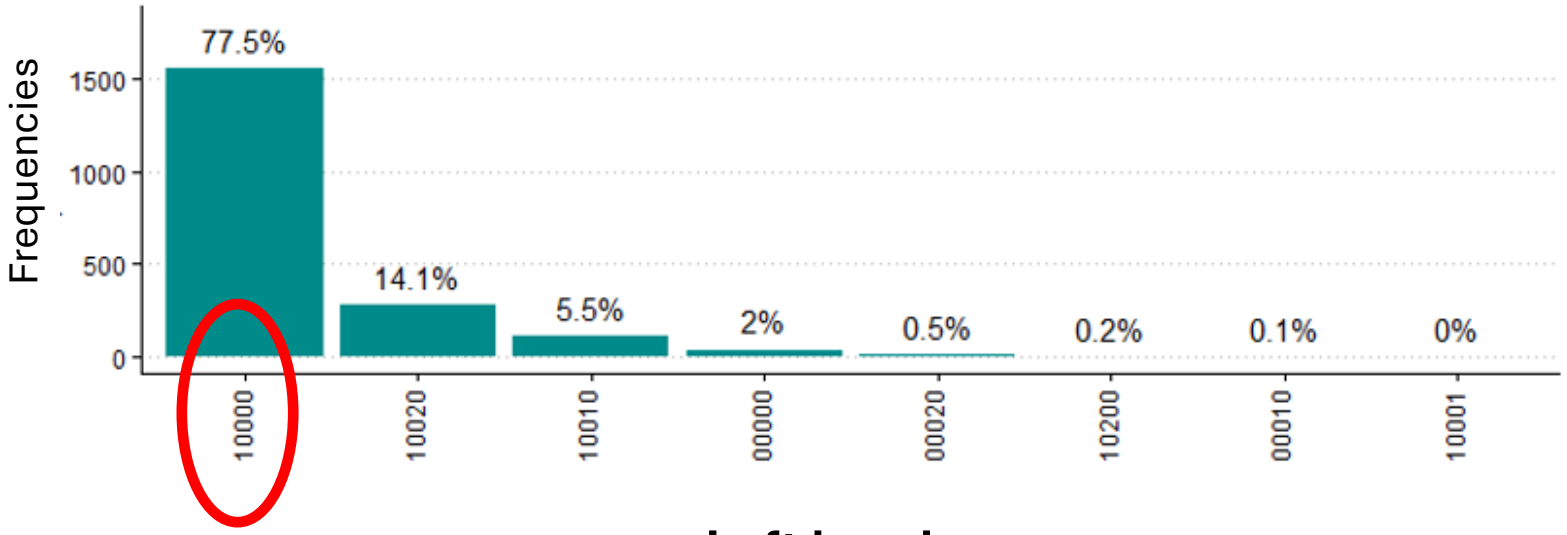
10 arrangements observed

7 common to both hands

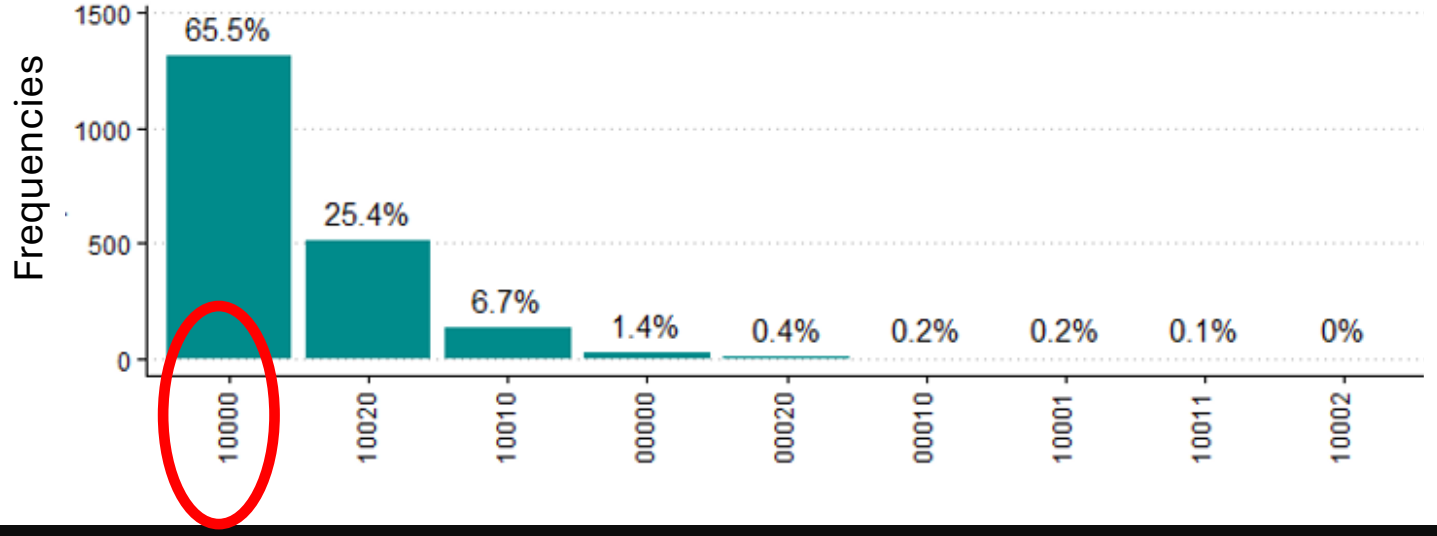
1 occurs exclusively in the right hand (F = 0.15%)

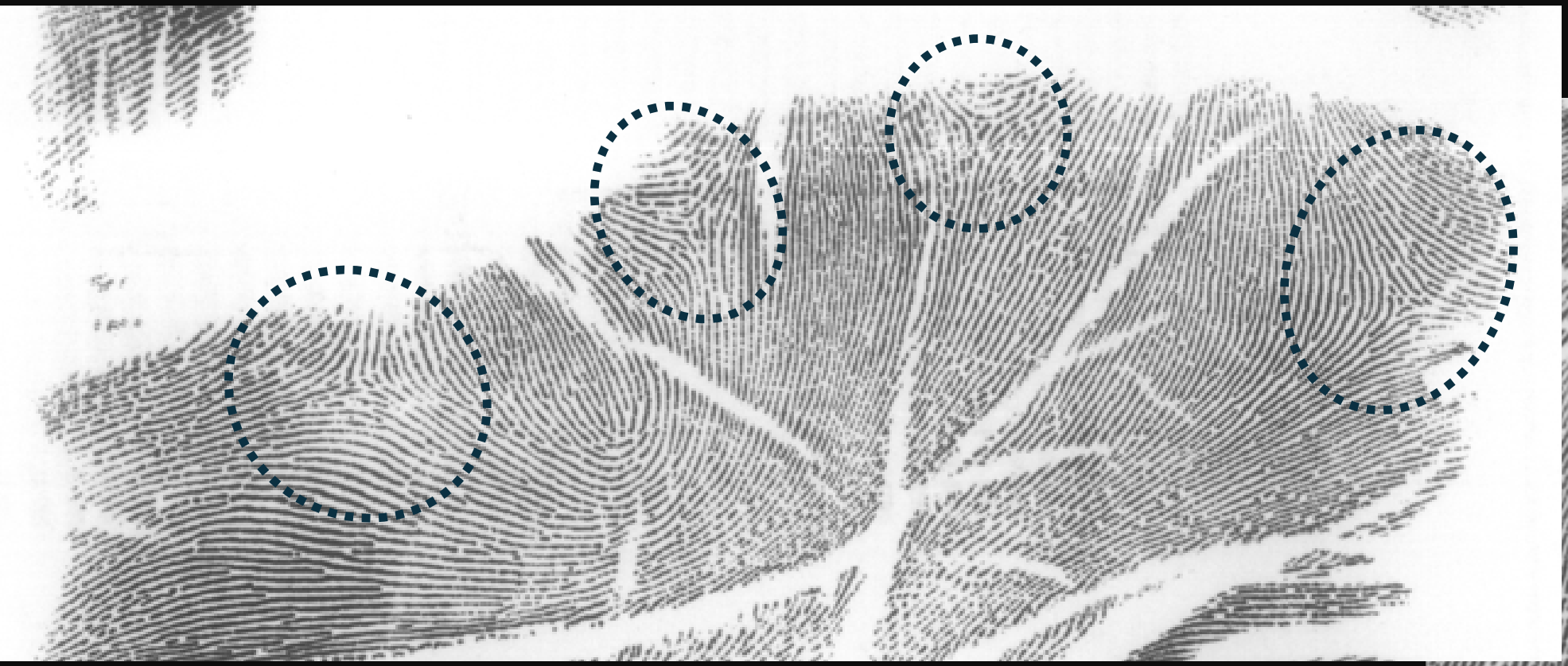
2 occur exclusively in the left hand (F = 0.06%)

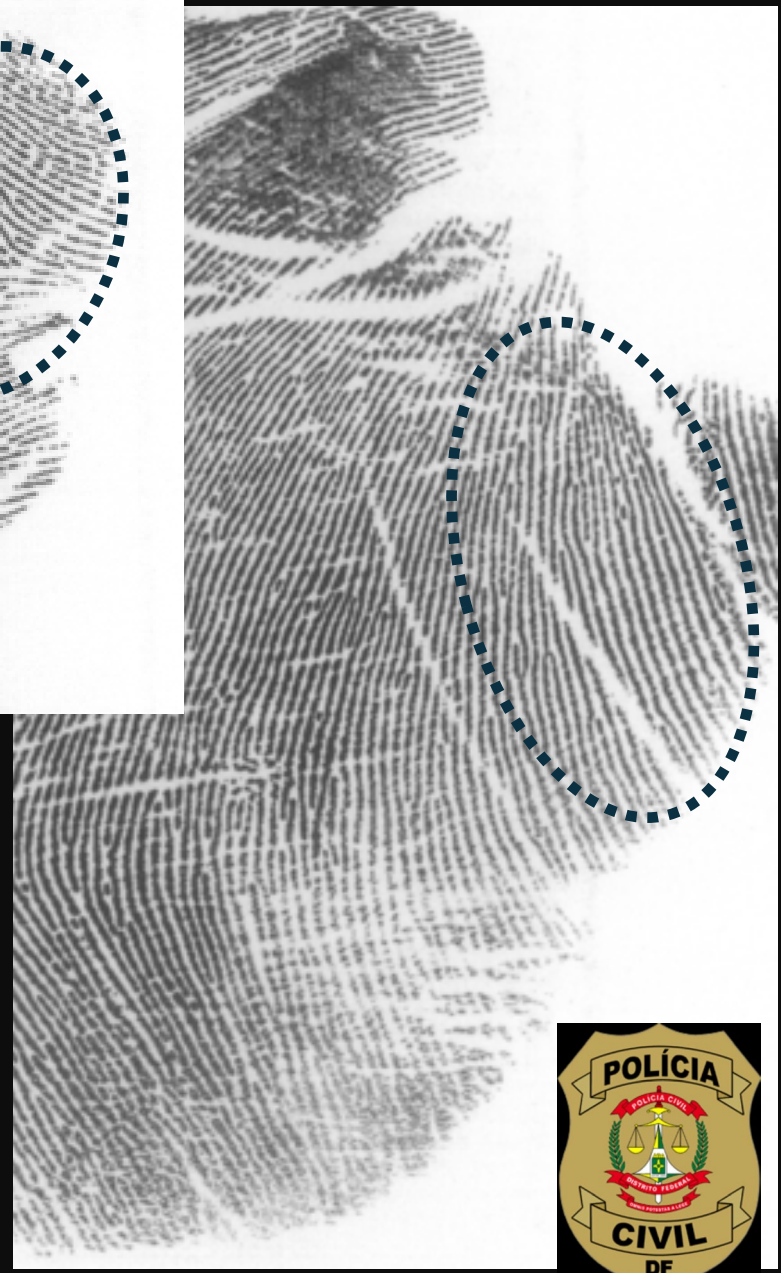
Right hand



Left hand

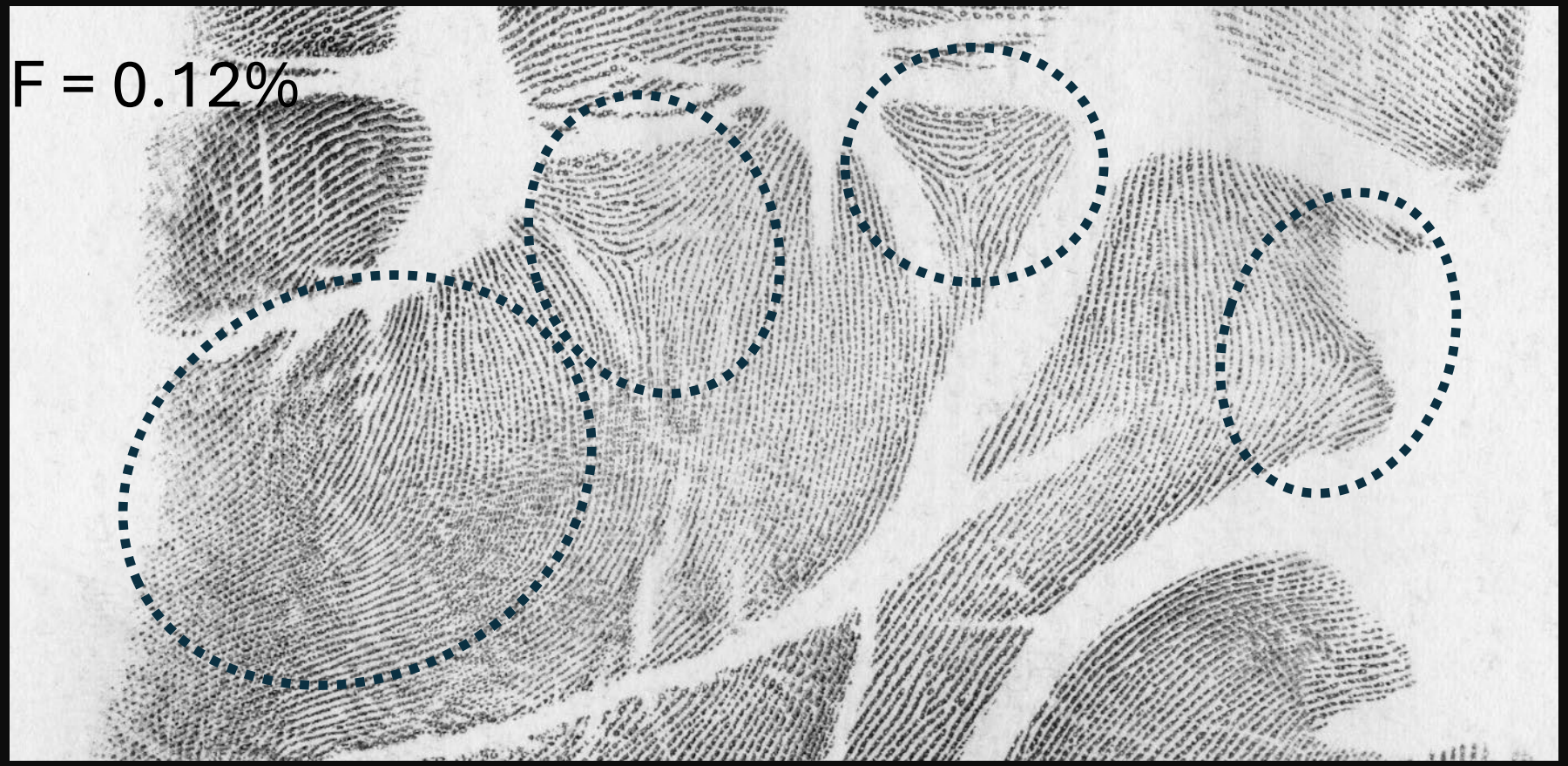


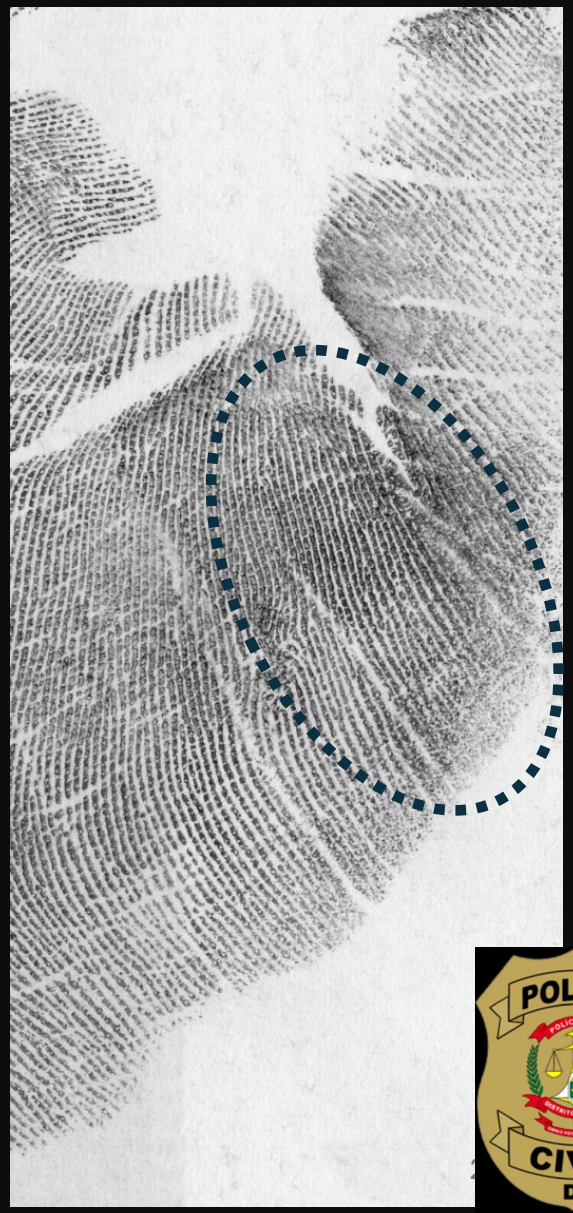




Most common arrangement on the bases: 1-0-0-0-0

B1	B2	B3	B4	B5
Plain arch –	delta –	delta –	delta –	delta





Rare arrangement that occur in both hands: 1-0-0-0-1

B1 B2 B3 B4 B5

plain arch – delta – delta – delta – plain arch

RESULTS

Arrangements on the intervals and bases analyzed in combination

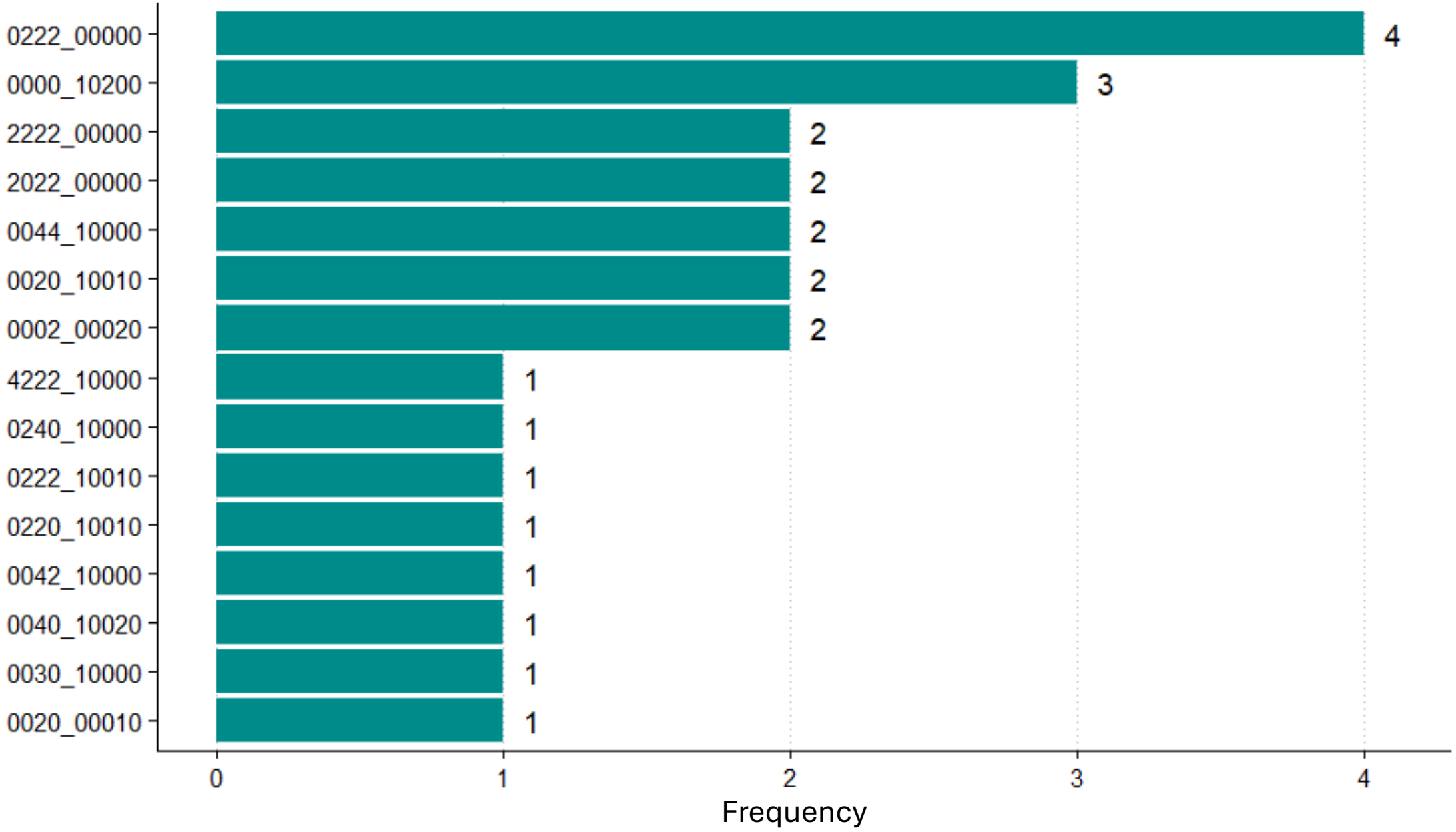
81 arrangements observed

36 common to both hands

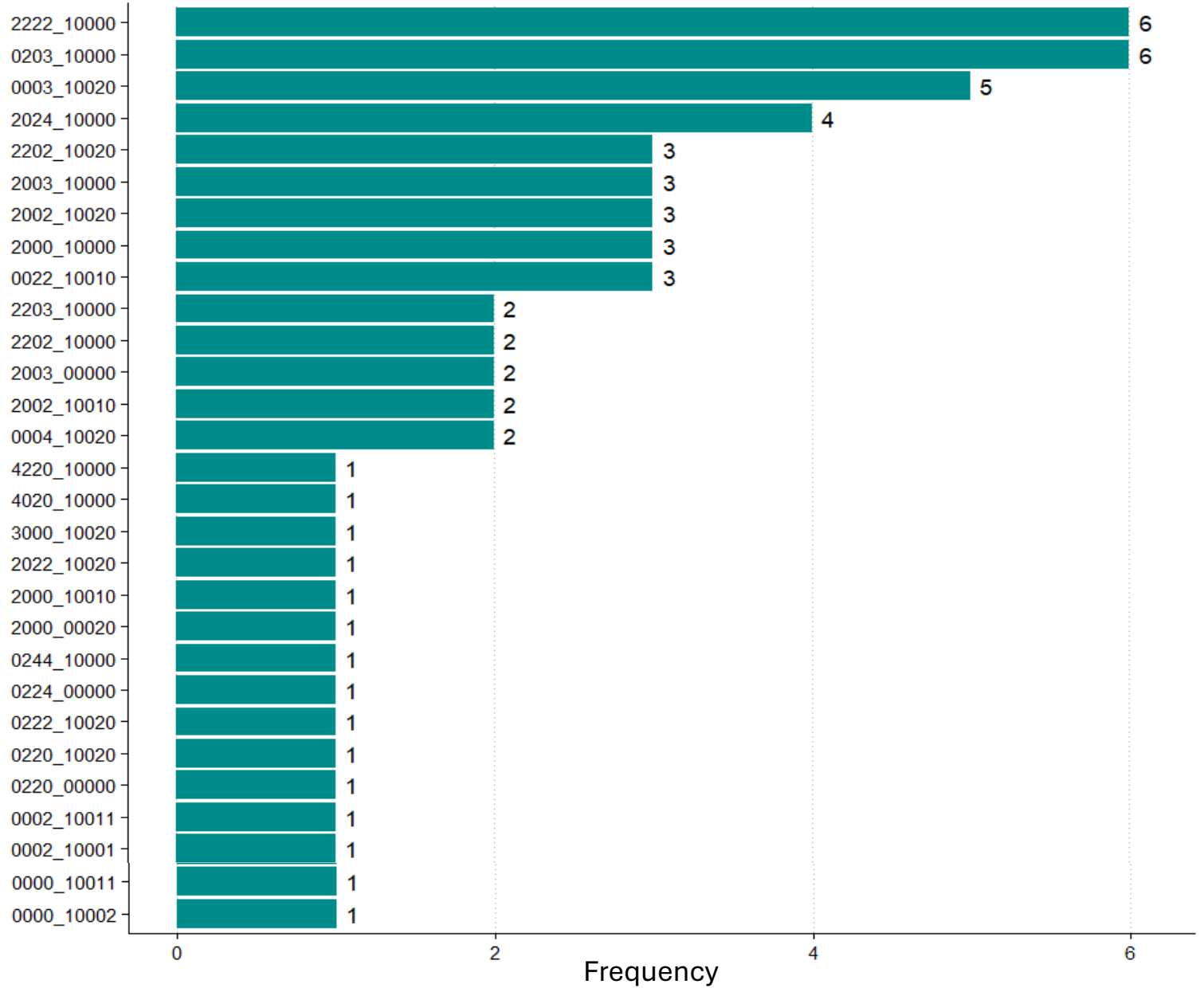
15 occur exclusively in the right hand (F < 0.2%)

29 occur exclusively in the left hand (F < 0.3%)

Arrangements occurring exclusively in the right hand

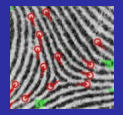


Arrangements occurring exclusively in the left hand



CONCLUSIONS

The interdigital region can be statistically classified as a unit.



Some arrangements are common, others rare, and some may never occur.

Additional tool in cases involving low-quality palm marks.

Enhancement of biometric identification efficiency in automated systems.

PART II

The relationship between the ridge patterning and the frequency of minutiae on the interdigital area of palmprints

Minutiae

Discriminating power.

It's the comparison of the relative positions of a set of minutiae (mark vs. print) that informs examiner's opinion.

What do we know about minutiae?

Vary qualitatively, quantitatively, and topologically.

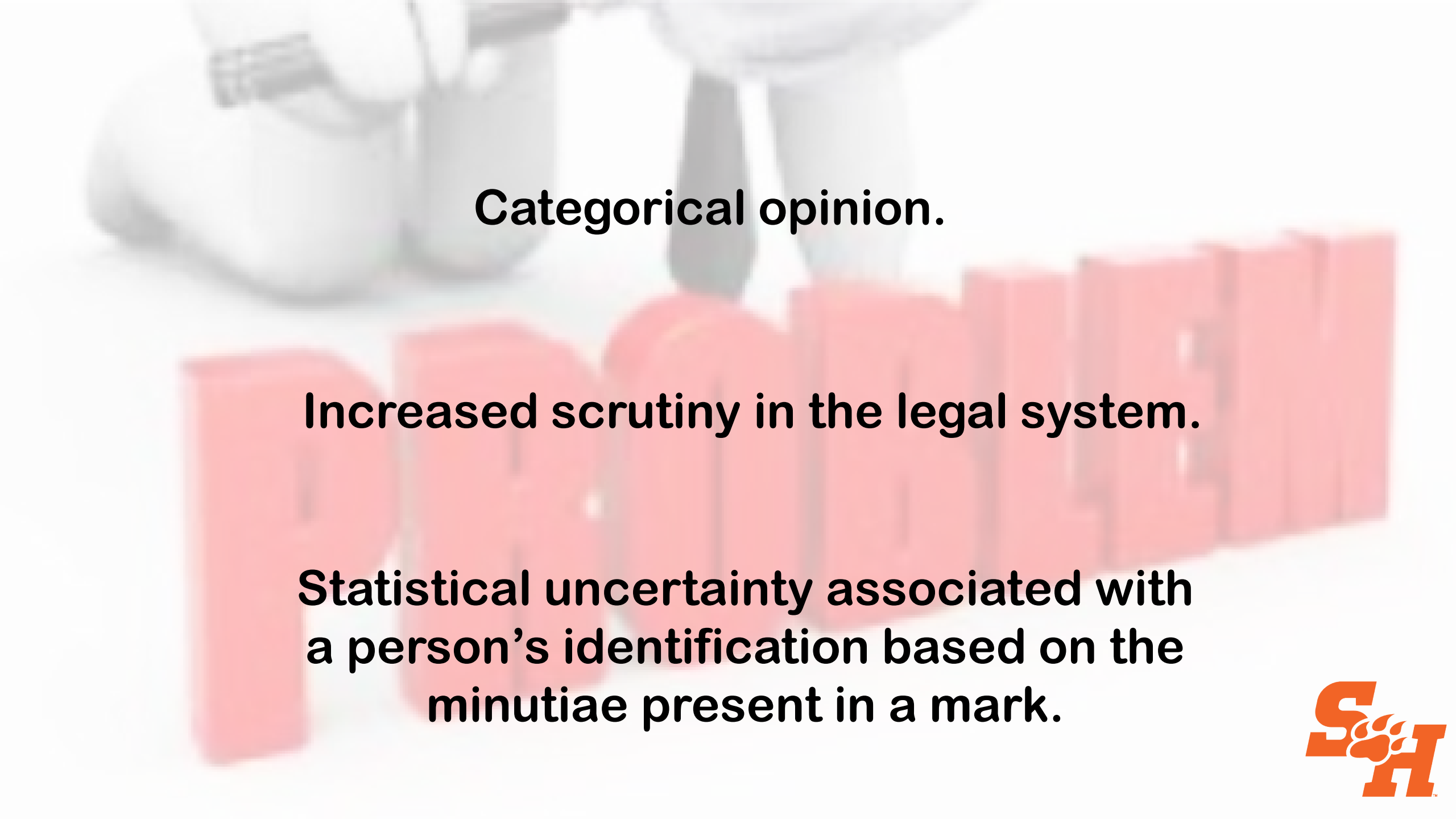
They are influenced by level 1 detail, sex, and ancestry.

Each type of minutiae has a different discriminatory value.

What do we know about minutiae in palmprints?

Sex and population variability of the number and distribution of minutia – interdigital, hypothenar, thenar.

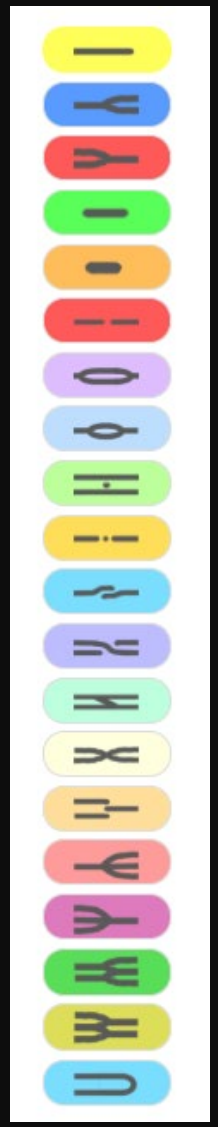
Frequency of 13 minutia types and their mutual occurrence on the hypothenar area of the palmprint.



Categorical opinion.

Increased scrutiny in the legal system.

Statistical uncertainty associated with a person's identification based on the minutiae present in a mark.



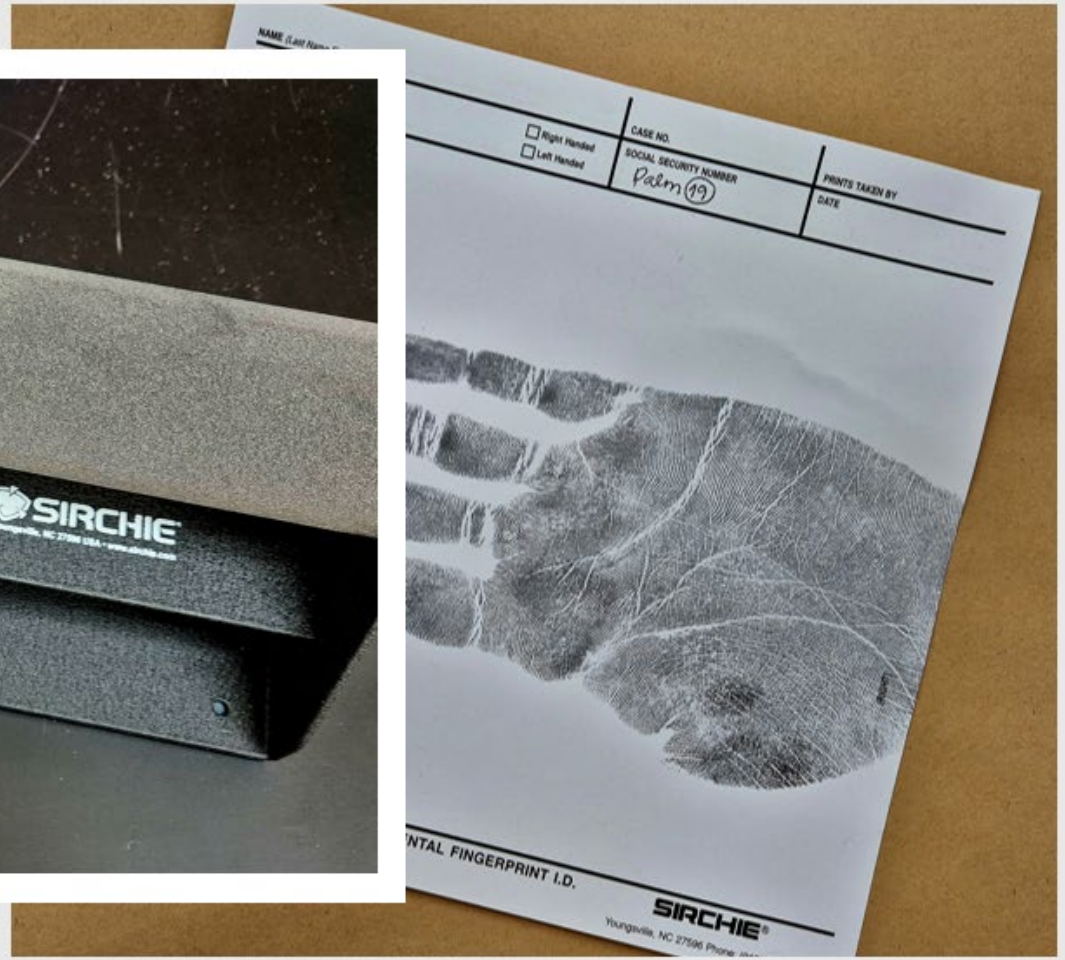
How to provide quantitative measure of weight of evidence to palmprint comparisons?

Frequency of minutiae

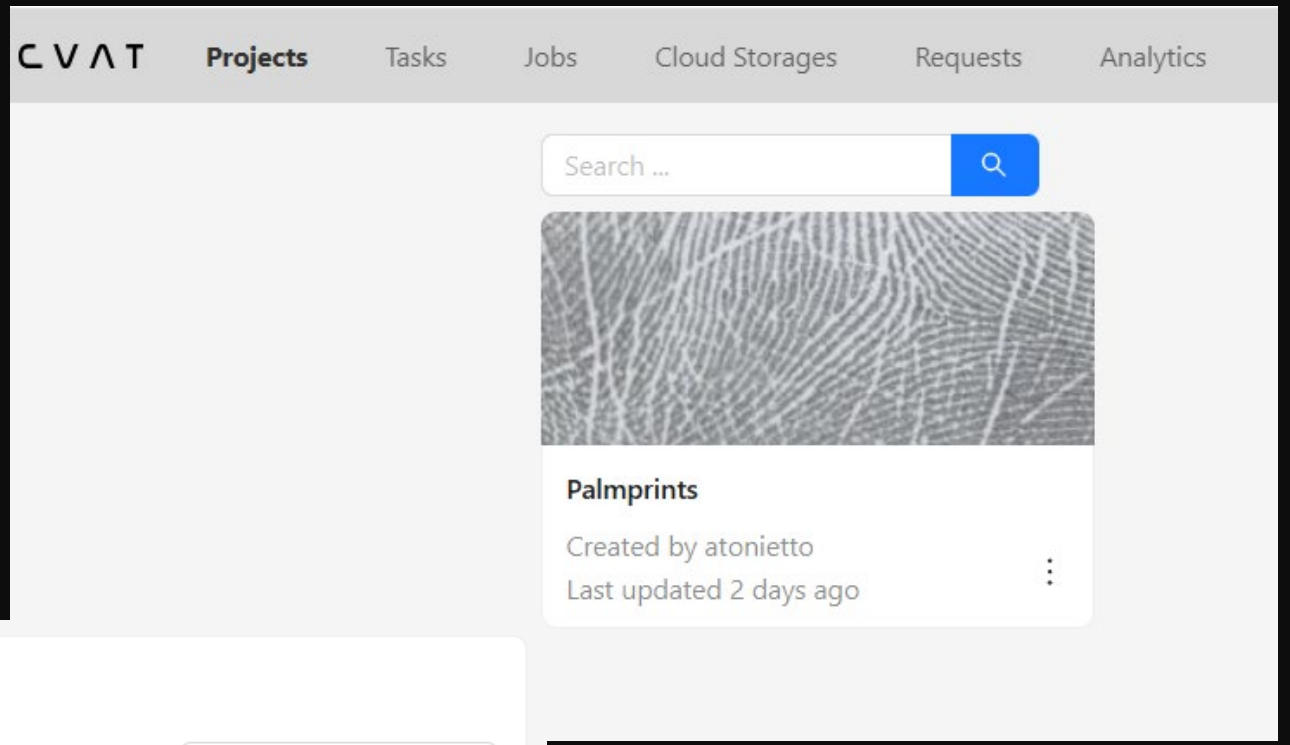
OBJECTIVES

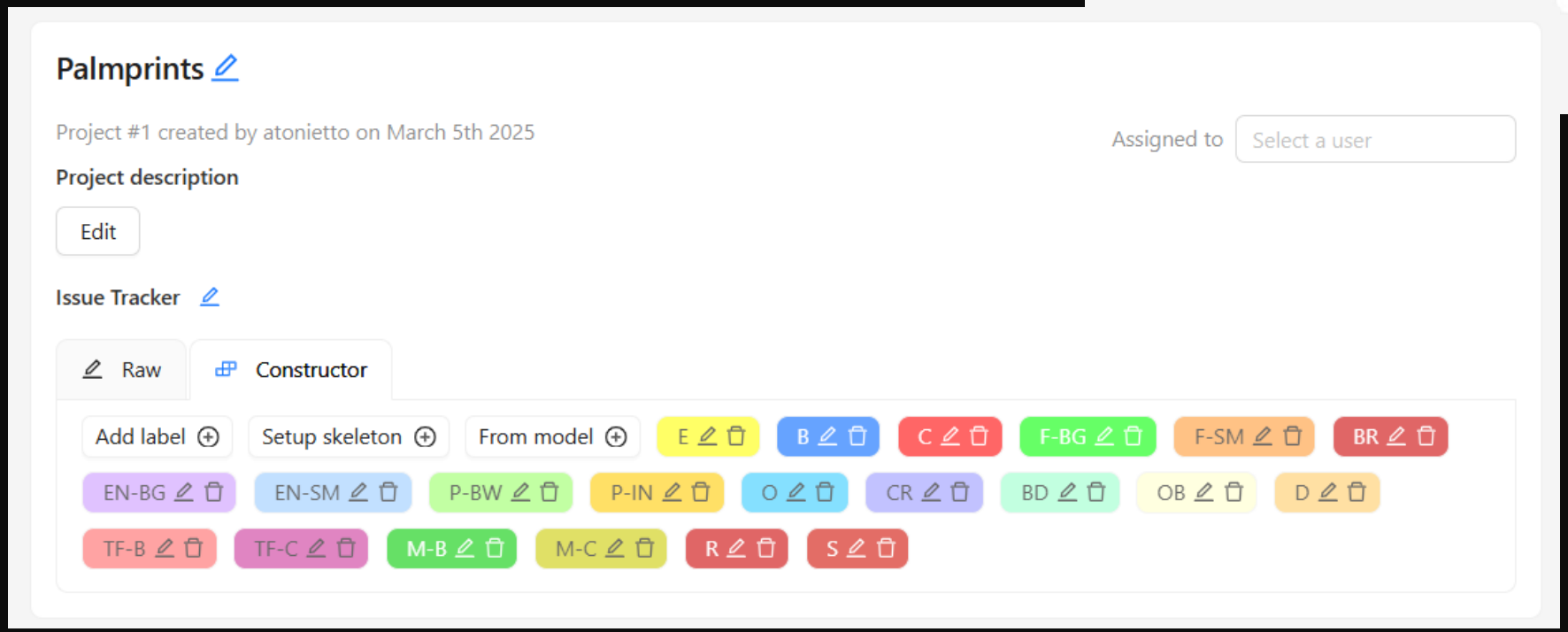
1. Count the frequency of general patterns in the sample, per hand and sex.
2. Count the frequency of minutia types on the interval 4.
3. Assess if the minutia type frequencies are statistically different between men and women.
4. Assess if there is an association between Level 1 and the frequency of minutiae.

METHODOLOGY

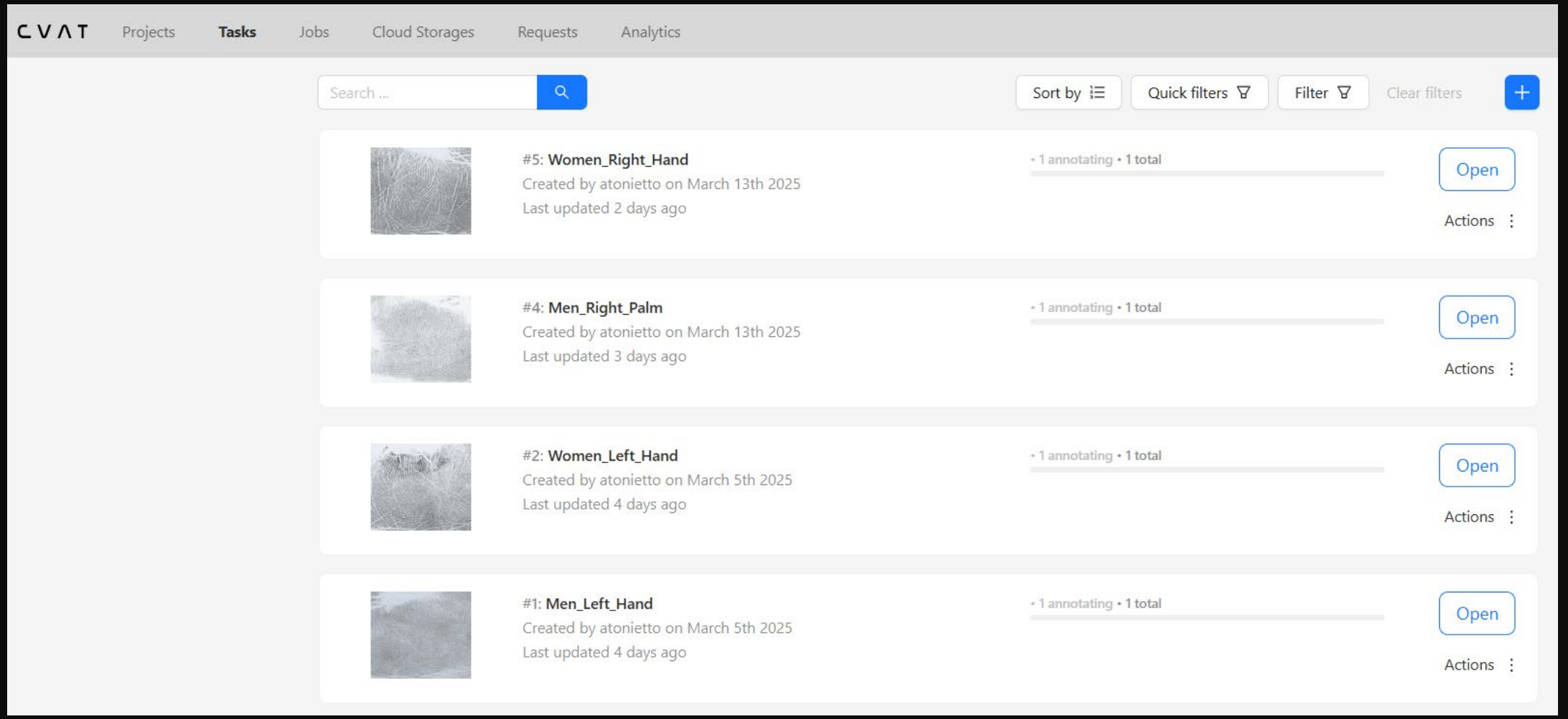


METHODOLOGY





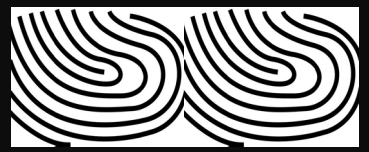
METHODOLOGY



Minutiae type		Definition
Ridge ending (E)		The termination of a ridge.
Bifurcation (B)		A point where a dermal ridge, originating from the left side of the palmprint, splits into two.
Convergence (C)		A point where two ridges, originating from the left side of the palmprint, merge into one.
Fragment Big (F-BG)		Short ridge with a length five to ten times its width.
Fragment Small (F-SM)		A short ridge with a length less than five times its width.
Break (BR)		A point where the course of a ridge is interrupted, in a way that the discontinuity is not less than the width of the ridge nor larger than double its width.
Enclosure Big (EN-BG)		Where the ridge path divides and then comes together again, with its length five to ten times the width of the dermal ridge.
Enclosure Small (EN-SM)		Where the ridge path divides and then comes together again with its length less than five times the width of the dermal ridge.
Point between (P-BW)		One ridge unit, containing only one sweat gland pore, between two ridges.
Point in ridge (P-IN)		One ridge unit, containing only one sweat gland pore within a ridge.

METHODOLOGY

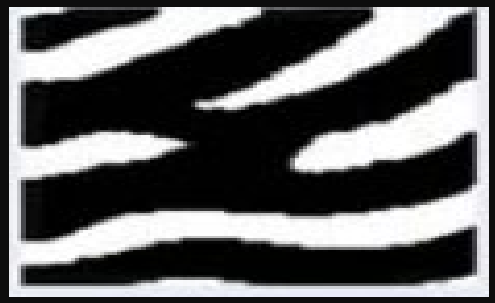
RESULTS - Frequency (%) of Level 1

Pattern	Both hands (n = 80)	Left hand (n = 40)	Right hand (n = 40)
	46%	52%	40%
	44%	30%	57%
	6%	10%	2%
	2%	2%	0
	1%	1%	0

RESULTS

7,380 minutiae were computed.

Merge C

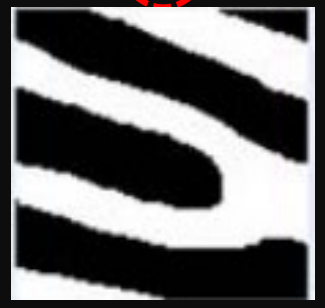


Merge B

Trifurcation B

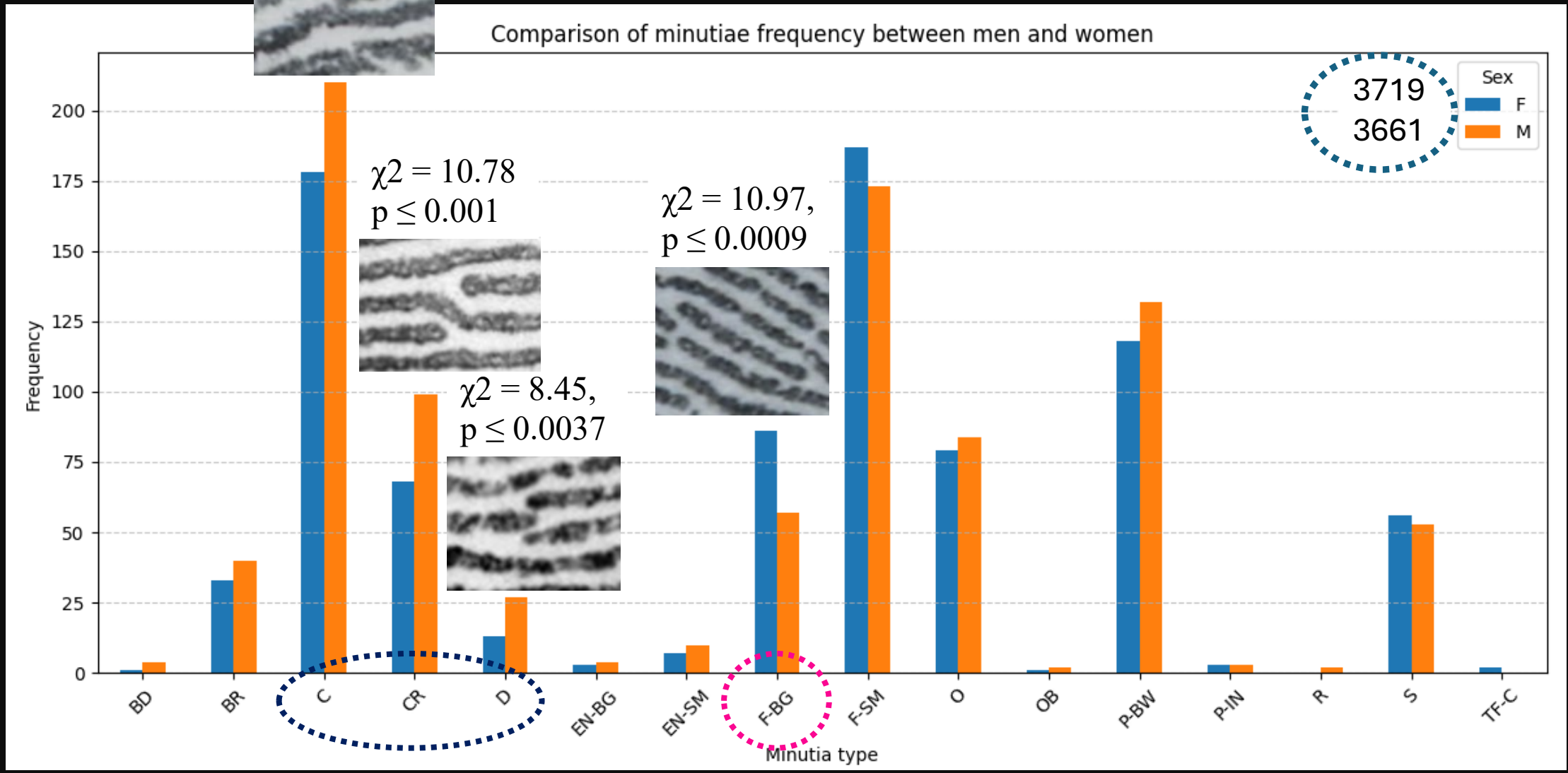
Left hand has 17.76% more minutiae than right hand.

Minutia	B	BD	BR	C	CR	D	E	EN-BG	EN-SM	F-BG	F-SM	O	OB	P-BW	P-IN	R	S	TF-C
RF (%)	7.56	0.06	0.98	5.25	2.26	0.54	68.29	0.09	0.23	1.93	4.87	2.2	0.04	3.38	0.08	0.02	1.47	0.02



RESULTS

$\chi 2 = 4.95, p \leq 0.026$

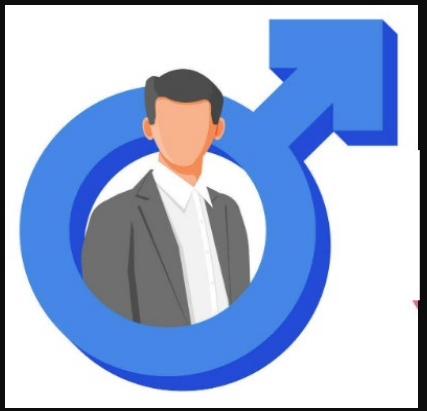


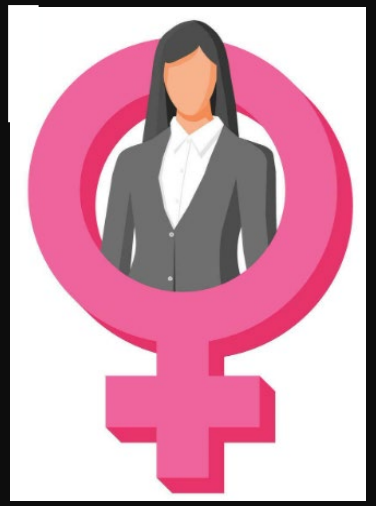
$\chi 2 = 10.78$
$p \leq 0.001$

$\chi 2 = 8.45,$
$p \leq 0.0037$

$\chi 2 = 10.97,$
$p \leq 0.0009$

E > B > C > F-SM > P-BW > CR > O > F-BG > S > BR >
D > EN-SM > BD > EN-BG > P-IN > OB > R > TF-C

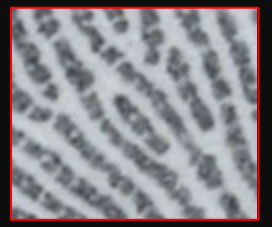




E > B > F-SM > C > P-BW > F-BG > O > CR > S >
BR > D > EN-SM > EN-BG > P-IN > TF-C > BD > OB > R

Relationship between Level 1 and Level 2

Minutia	Test	p-value
B	Chi-Square	0.2076
BD	Fisher (sim)	0.7827
BR	Fisher (sim)	0.3121
C	Chi-Square	0.0574
CR	Chi-Square	0.2664
D	Fisher (sim)	0.7428
E	Chi-Square	0.8480
EN-BG	Fisher (sim)	0.4270
EN-SM	Fisher (sim)	1.0000
F-BG	Fisher (sim)	0.0171*
F-SM	Chi-Square	0.0124*
O	Chi-Square	0.6977
OB	Fisher (sim)	0.3340
P-BW	Chi-Square	0.9190
P-IN	Fisher (sim)	0.0104*
R	Fisher (sim)	0.0734
S	Fisher (sim)	1.0000
TF-C	Fisher (sim)	0.0821



CONCLUSION

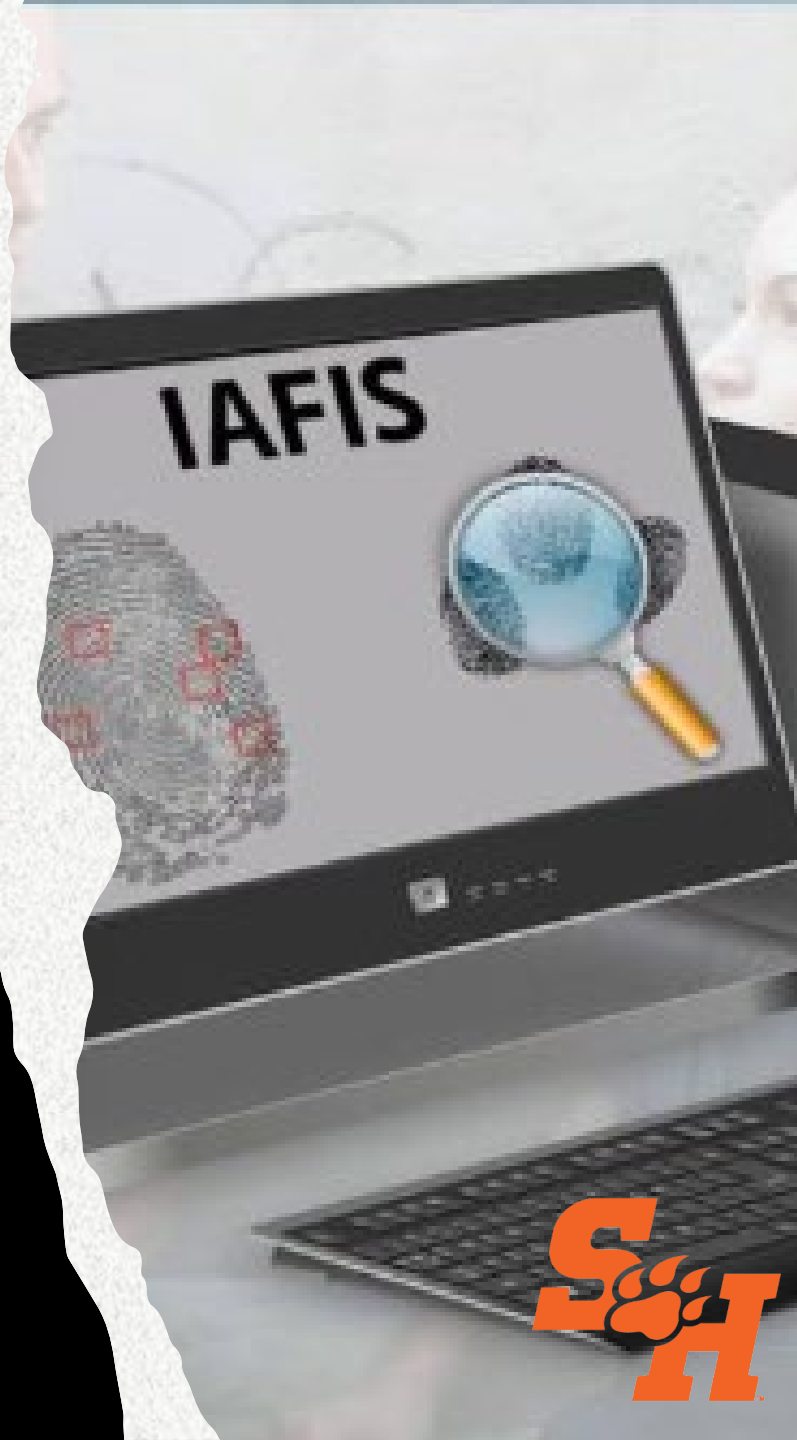
The importance of less common minutia types.

Findings also challenge previous research on sex-based minutiae differences.

The necessity of standardizing minutiae classification to enhance comparison across populations.

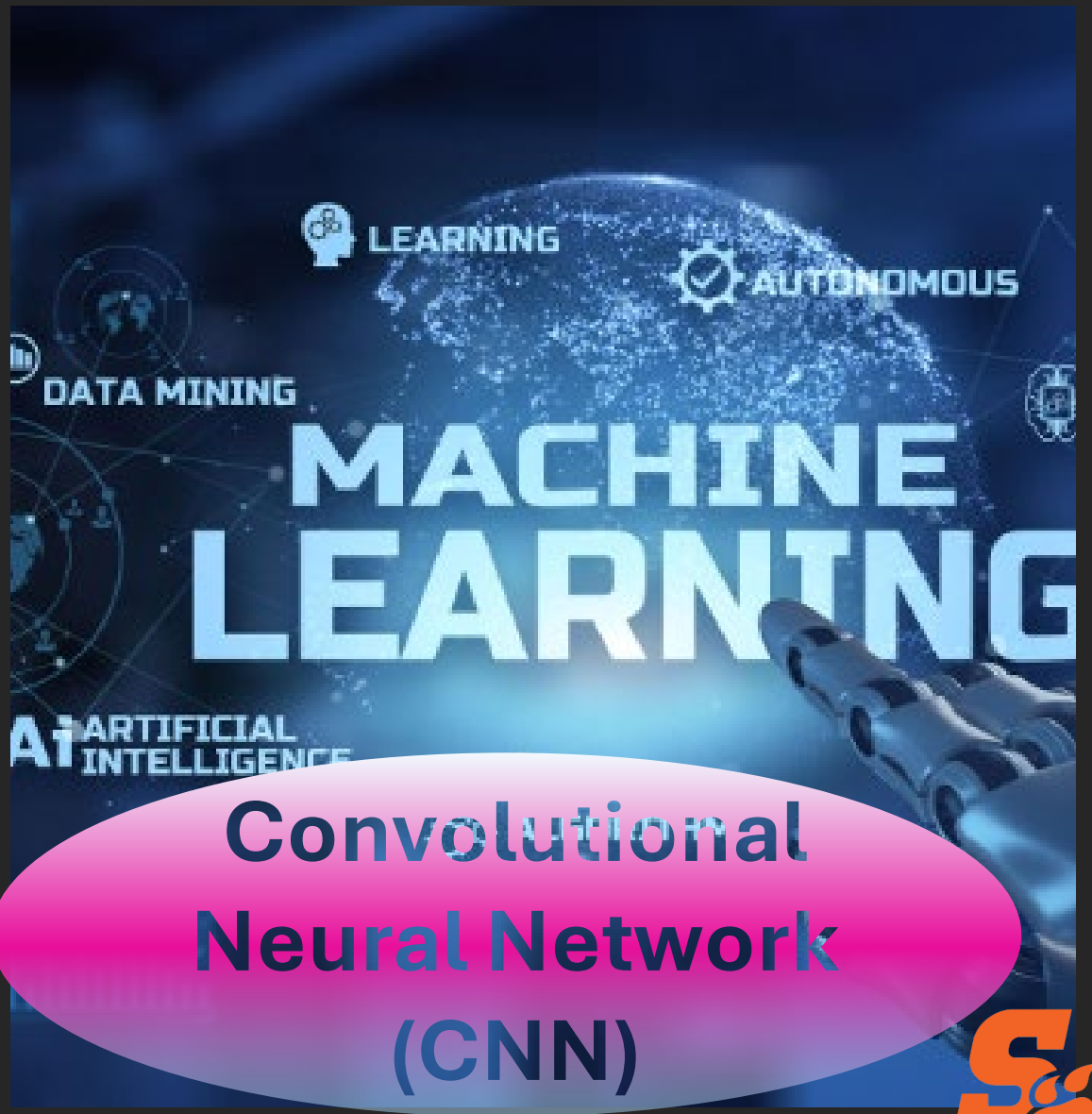
Automated detection and frequency-based interpretation of palmprint features for friction ridge examinations

Automation of friction ridge examinations



DEEP ARCHITECTURES

- Stronger representative capacity
- Can learn more abstract features
- Greater learning competence
- Better generalization performance



Convolutional Neural Network (CNN)

CONVOLUTIONAL NEURAL NETWORK

Learn minutiae patterns

Detect them accurately

OBJECTIVES

Training a model to automatically detect and classify Level 1 and Level 2 features in pristine palmprints.

Automatically counting and storing their respective relative frequencies, as well as updating the database every time new palmprints are inserted.

Questions?

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