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Forensic Anthropology Society Europe
A section of the International Academy of Legal Medicine

ONE DAY FASE SYMPOSIUM SEPTEMBER 5th, 2015

UNIVERSITÀ DEGLI STUDI DI MILANO

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Positive identification by hand X-rays superimposition: a quantitative approach

Silvio Giancola, Daniele Gibelli, Stefania Vergini, Sara Candosin, Debora Mazzarelli, Remo Sala, Cristina Cattaneo

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Introduction

Unidentified bodies: a social emergency

- Unidentified body represents 3.1% of all autopsies (Milan)
- Similar percentages are reported also in USA (4.4% of unknown decedents every year, and 2.6% are to become “cold cases”)
- 78% of cases die by traumatic causes (and 22.6% by homicide)
- Main reasons are loosening of familiar links and migration flows

Forensic Science International 195 (2010) 167.e1–167.e6

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Forensic anthropology population data

Unidentified bodies and human remains: An Italian glimpse through a European problem

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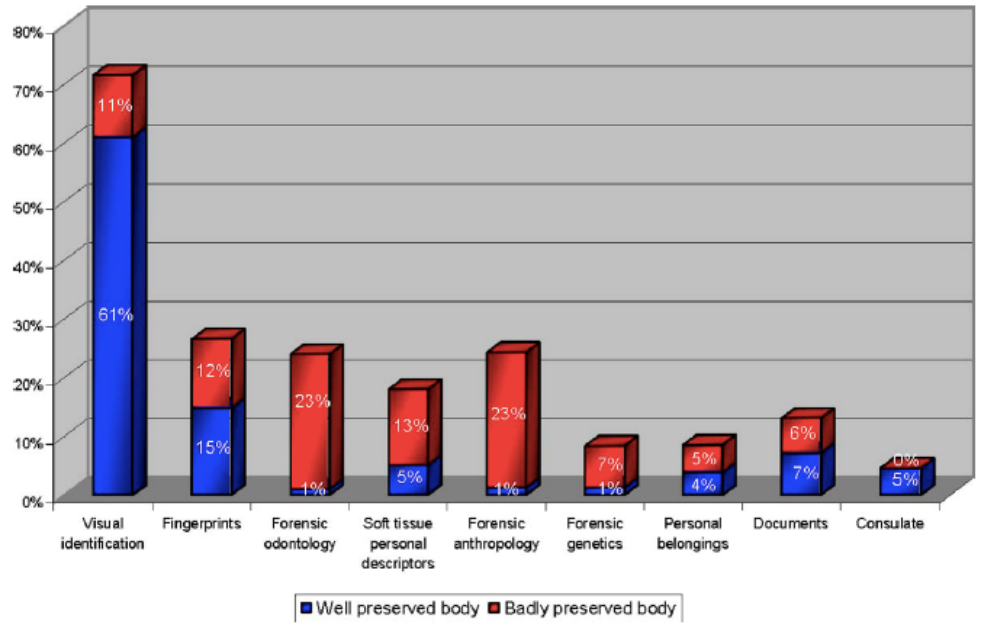

SUMMARY

- **Introduction**
- Pilot Study
- Automatic comparison
- Results
- Conclusion

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Introduction

Importance of bone features for identification

- Prothesis and surgical devices → Easily comparable (in some cases ID)


JOURNAL OF FORENSIC SCIENCES

J Forensic Sci, March 2011, Vol. 56, No. 2
doi: 10.1111/j.1556-4029.2010.01639.x
Available online at: onlinelibrary.wiley.com

TECHNICAL NOTE

ANTHROPOLOGY

Rebecca J. Wilson,[1] M.A.; Jonathan D. Bethard,[1,2] M.A.; and Elizabeth A. DiGangi,[3] Ph.D.

The Use of Orthopedic Surgical Devices for Forensic Identification*

- Pathological and previous traumatic lesions (bone calluses) → Abnormal and highly individualizing

- Physiological features (anatomical characteristics) → Modification are often limited and difficult to quantify

SUMMARY

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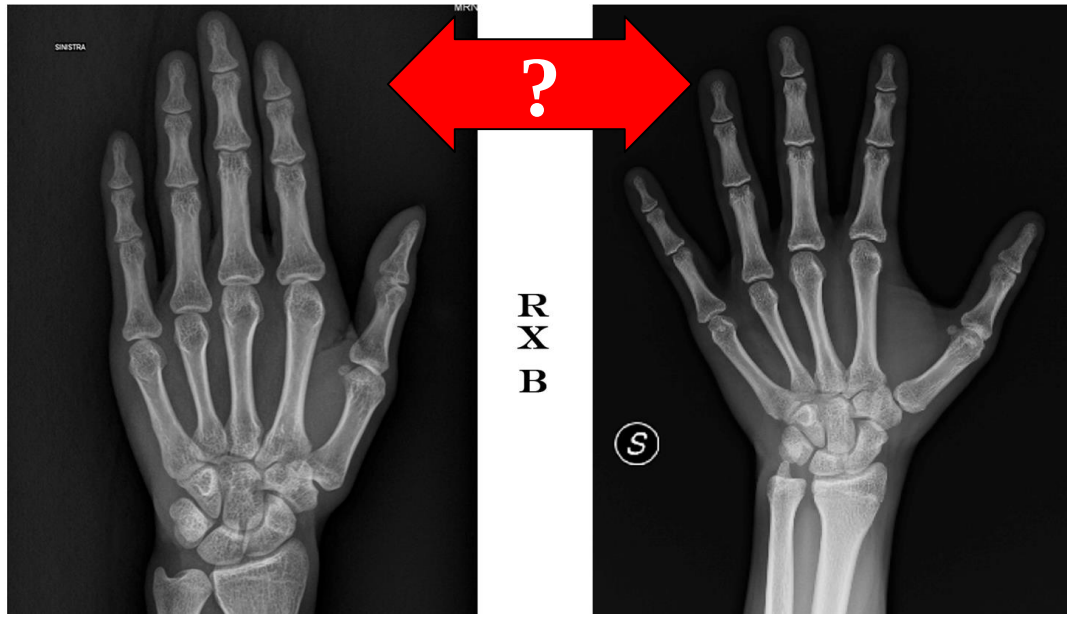
Introduction

Personal identification in hands:

- Looking for individual **peculiarities**
- Comparison of **similarities and differences**
- **Recognition** of people

RXA



RXB

SUMMARY

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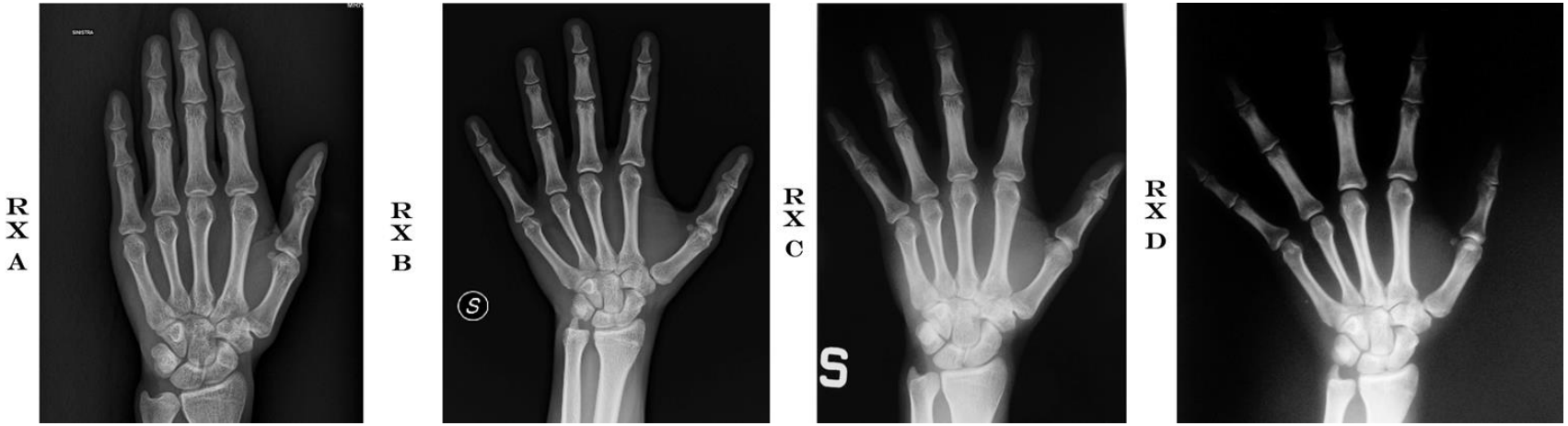
Introduction

Our main goal:

- Find a **quantitative** method for the personal identification through hand X-rays superimposition:
  - Find **bones features** that can characterize a person
  - Find similarities between these features in a **couple** of X-rays scans,
  - Find resemblances between a full **dataset** of X-rays scans,
  - **Identify** a person by its X-rays scan.



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Pilot Study

- **Blind tests:**
  - 15 identifying blind tests,
  - 34 observers with different background,
  - Scores are measured in percentage of correct answers by observer.

- **Results:**
  - Forensic Anthropologist / Odontologist : **76%** of correct answers
  - Anthropology Students: **67%** of correct answers
  - Forensic Pathologists: **65%** of correct answers

    - *Results are **not particularly high***
    - ***Shapes analysis** are done by observers*

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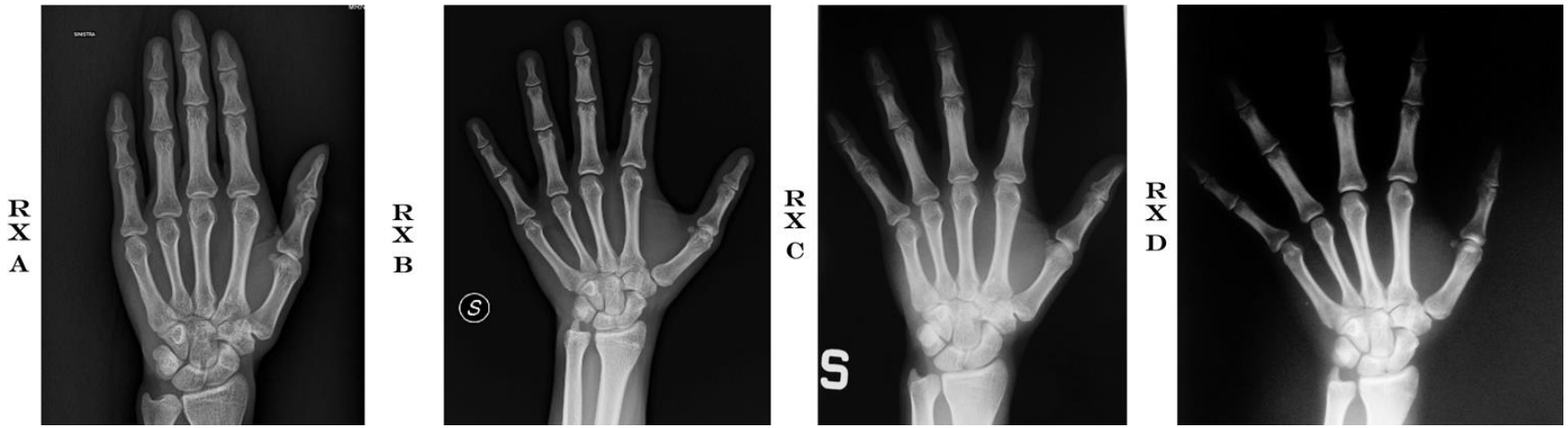
Automatic comparison

- **X-rays dataset:**
  - 9 adults, AM, without pathologies
  - 2 people with 3 scans
  - 7 people with a single scans

- **Notation: *X.Y***, ***X*** being the person index, ***Y*** the index of the scan acquisition
  - *Ex: 2.3 represent the 3rd acquisition of the 2nd person*



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Automatic comparison

- **HALCON:** Computer vision software for industrial and medical purpose
  - Geometrical measurements with cameras
  - Elaboration of 2D and 3D imagery
  - State of the art algorithms
  - Well documented examples
  - Useful tools for camera acquisition, calibration, matching, …

HALCON
the power of machine vision

- **Object recognition / Matching**: Recognition of a model in an image
  - **Shape-Based** Matching: **edge/contour** detection
  - **Deformable** Matching: **deformed edge/contour** detection
  - **Correlation-Based** Matching: **pattern/kernel** recognition
  - **Descriptor-Based** Matching: **keypoints/features** detection

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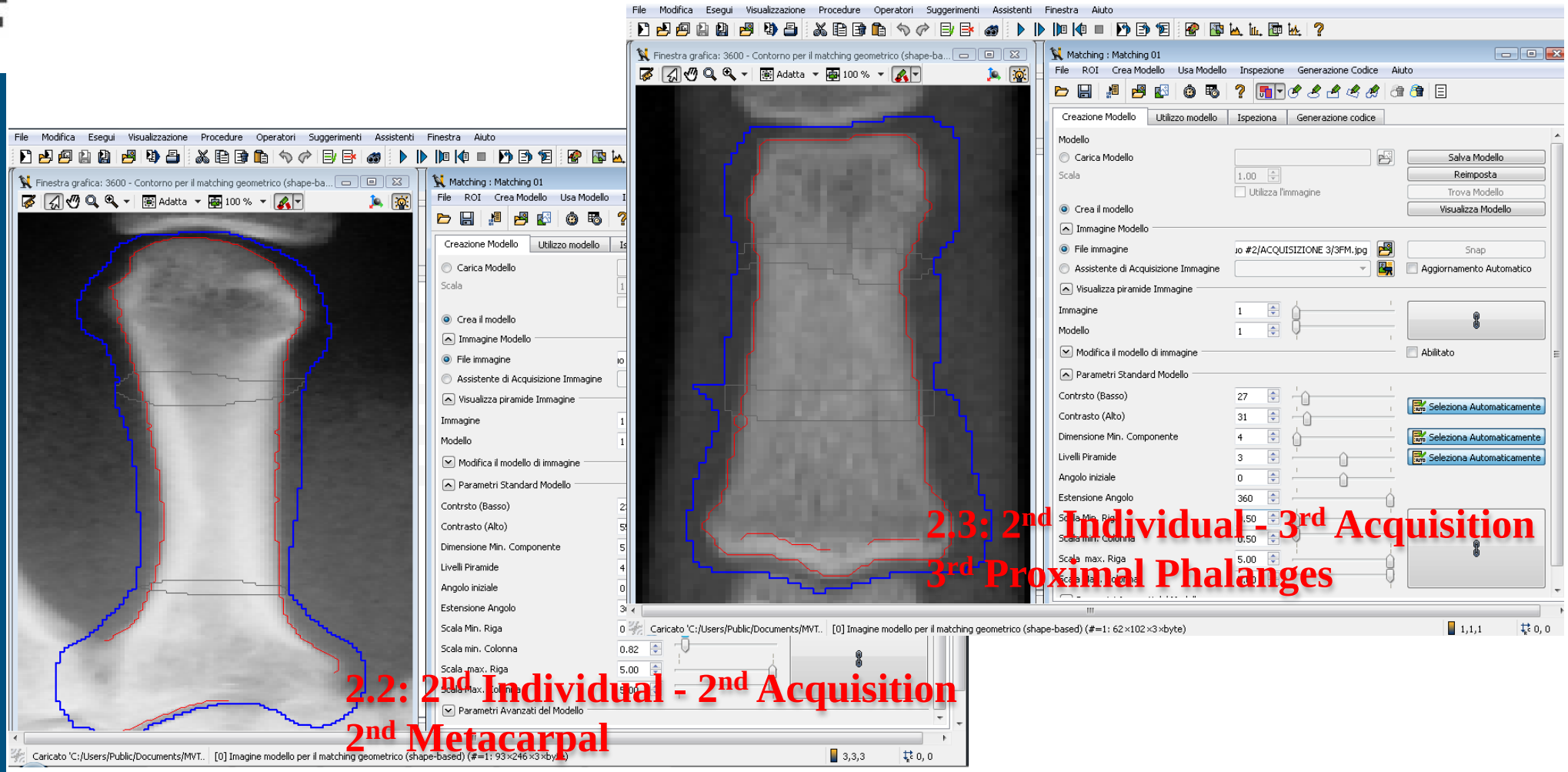
Automatic comparison

- **Segmentation** of a X-rays acquisition in multiple **rigid bodies** (bones)

SUMMARY

Automatic comparison

- Identification of **features**
  - Shape Based: **contour** identification



SUMMARY

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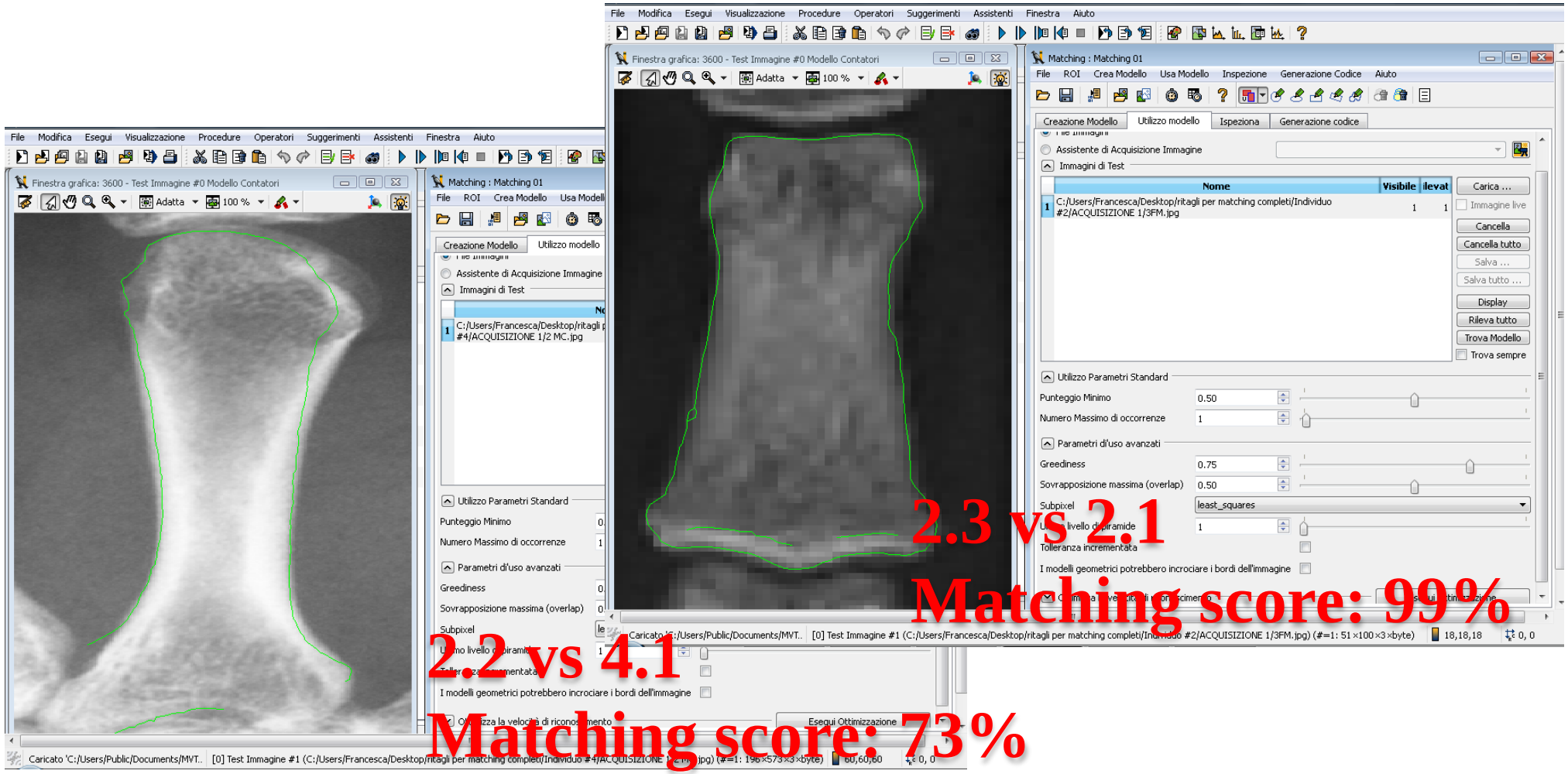
Automatic comparison

- **Cross comparison** between scans of the dataset
  - Returns a **matching score**



SUMMARY

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Results

Ind#2 Acq#1			Metacarpals					Proximal phalanges					Intermediate phalanges				Hand
Image	**Individual**	**Acquisition**	**MC1**	**MC2**	**MC3**	**MC4**	**MC5**	**PP1**	**PP2**	**PP3**	**PP4**	**PP5**	**IP2**	**IP3**	**IP4**	**IP5**	**Score**
1	Ind #1	Acq #1	72%	83%	84%	72%	65%	91%	63%	80%	87%	96%	86%	94%	95%	88%	**81.87%**
2	Ind #1	Acq #2	80%	70%	80%	77%	83%	92%	61%	80%	80%	97%	79%	93%	93%	93%	**82.12%**
3	Ind #1	Acq #3	85%	81%	96%	75%	90%	86%	63%	81%	66%	91%	69%	93%	92%	92%	**82.16%**
4	Ind #2	Acq #1	99%	100%	100%	100%	100%	99%	100%	99%	99%	100%	99%	98%	95%	95%	**98.77%**
5	Ind #2	Acq #2	91%	100%	98%	98%	99%	92%	97%	95%	94%	97%	94%	95%	99%	92%	**95.74%**
6	Ind #2	Acq #3	89%	98%	93%	97%	99%	94%	97%	95%	94%	99%	96%	97%	97%	91%	**95.39%**
7	Ind #3	Acq #1	81%	99%	89%	66%	76%	92%	79%	68%	76%	93%	67%	85%	92%	91%	**81.76%**
8	Ind #4	Acq #1	82%	98%	71%	69%	74%	88%	74%	70%	73%	93%	68%	89%	93%	95%	**80.53%**
9	Ind #5	Acq #1	84%	97%	87%	73%	75%	78%	74%	67%	70%	93%	70%	89%	97%	95%	**81.40%**
10	Ind #6	Acq #1	83%	91%	92%	74%	96%	76%	75%	69%	76%	93%	66%	98%	97%	95%	**83.62%**
11	Ind #7	Acq #1	83%	92%	92%	75%	92%	84%	75%	68%	70%	94%	70%	95%	99%	95%	**83.89%**
12	Ind #8	Acq #1	83%	99%	86%	74%	86%	80%	79%	73%	73%	93%	77%	89%	94%	89%	**83.55%**
13	Ind #9	Acq #1	83%	93%	88%	73%	82%	96%	84%	74%	81%	95%	77%	97%	94%	98%	**86.37%**

Ind#2 Acq#2			Metacarpals					Proximal phalanges					Intermediate phalanges				Hand
Image	**Individual**	**Acquisition**	**MC1**	**MC2**	**MC3**	**MC4**	**MC5**	**PP1**	**PP2**	**PP3**	**PP4**	**PP5**	**IP2**	**IP3**	**IP4**	**IP5**	**Score**
1	Ind #1	Acq #1	74%	91%	82%	77%	57%	76%	82%	90%	78%	88%	76%	97%	87%	81%	**80.56%**
2	Ind #1	Acq #2	85%	71%	92%	77%	79%	87%	77%	69%	73%	93%	75%	96%	91%	85%	**81.70%**
3	Ind #1	Acq #3	88%	76%	98%	83%	88%	87%	83%	94%	80%	90%	74%	93%	86%	74%	**84.98%**
4	Ind #2	Acq #1	94%	96%	99%	98%	98%	76%	97%	97%	98%	96%	92%	98%	96%	95%	**94.82%**
5	Ind #2	Acq #2	100%	100%	100%	100%	100%	99%	100%	100%	100%	100%	100%	100%	100%	99%	**99.86%**
6	Ind #2	Acq #3	97%	99%	99%	97%	98%	89%	95%	97%	98%	97%	93%	99%	97%	96%	**96.46%**
7	Ind #3	Acq #1	73%	73%	92%	57%	52%	60%	78%	56%	64%	58%	55%	82%	77%	72%	**66.82%**
8	Ind #4	Acq #1	71%	71%	86%	51%	68%	51%	72%	77%	62%	52%	63%	94%	81%	79%	**68.68%**
9	Ind #5	Acq #1	62%	73%	91%	64%	74%	55%	58%	61%	67%	64%	67%	91%	82%	79%	**69.73%**
10	Ind #6	Acq #1	73%	72%	84%	66%	74%	56%	72%	87%	90%	76%	66%	96%	86%	86%	**76.67%**
11	Ind #7	Acq #1	72%	76%	87%	71%	76%	56%	81%	91%	92%	83%	75%	95%	89%	88%	**80.15%**
12	Ind #8	Acq #1	79%	76%	89%	63%	68%	56%	78%	82%	66%	80%	70%	94%	84%	72%	**74.82%**
13	Ind #9	Acq #1	83%	68%	94%	69%	80%	60%	83%	89%	92%	79%	72%	96%	87%	89%	**80.79%**

SUMMARY

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Results

Ind#1 Acq#1			Metacarpals					Proximal phalanges					Intermediate phalanges				Hand
Image	**Individual**	**Acquisition**	**MC1**	**MC2**	**MC3**	**MC4**	**MC5**	**PP1**	**PP2**	**PP3**	**PP4**	**PP5**	**IP2**	**IP3**	**IP4**	**IP5**	**Score**
1	Ind #1	Acq #1	100%	100%	100%	100%	100%	99%	100%	100%	99%	99%	100%	100%	100%	100%	**99.78%**
2	Ind #1	Acq #2	84%	94%	95%	89%	83%	78%	90%	96%	94%	97%	98%	93%	89%	94%	**90.82%**
3	Ind #1	Acq #3	80%	100%	97%	90%	91%	79%	93%	97%	96%	93%	83%	82%	69%	65%	**86.12%**
4	Ind #2	Acq #1	67%	94%	78%	59%	65%	66%	86%	87%	93%	93%	94%	95%	96%	66%	**80.20%**
5	Ind #2	Acq #2	62%	97%	75%	59%	67%	72%	81%	84%	90%	96%	83%	87%	86%	57%	**77.20%**
6	Ind #2	Acq #3	68%	89%	74%	56%	64%	66%	85%	88%	92%	96%	98%	95%	98%	73%	**80.33%**
7	Ind #3	Acq #1	39%	91%	70%	50%	57%	48%	61%	53%	58%	79%	64%	57%	61%	53%	**58.82%**
8	Ind #4	Acq #1	54%	85%	64%	58%	58%	58%	71%	54%	67%	78%	63%	67%	69%	61%	**64.24%**
9	Ind #5	Acq #1	45%	80%	65%	55%	55%	52%	54%	51%	59%	73%	44%	69%	71%	52%	**58.02%**
10	Ind #6	Acq #1	52%	83%	60%	56%	59%	55%	51%	64%	66%	80%	48%	55%	66%	53%	**59.81%**
11	Ind #7	Acq #1	56%	74%	59%	52%	57%	61%	70%	69%	68%	82%	65%	65%	66%	55%	**63.74%**
12	Ind #8	Acq #1	48%	85%	62%	53%	47%	60%	71%	63%	58%	78%	53%	65%	75%	52%	**61.17%**
13	Ind #9	Acq #1	59%	80%	65%	62%	59%	62%	61%	68%	67%	88%	65%	63%	69%	54%	**65.36%**

Ind#1 Acq#2			Metacarpals					Proximal phalanges					Intermediate phalanges				Hand
Image	**Individual**	**Acquisition**	**MC1**	**MC2**	**MC3**	**MC4**	**MC5**	**PP1**	**PP2**	**PP3**	**PP4**	**PP5**	**IP2**	**IP3**	**IP4**	**IP5**	**Score**
1	Ind #1	Acq #1	97%	98%	99%	98%	95%	91%	94%	99%	93%	94%	99%	96%	99%	82%	**95.18%**
2	Ind #1	Acq #2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%	100%	100%	98%	**99.78%**
3	Ind #1	Acq #3	99%	99%	100%	99%	96%	98%	97%	99%	98%	93%	96%	99%	98%	68%	**95.25%**
4	Ind #2	Acq #1	93%	87%	98%	83%	71%	95%	92%	97%	91%	95%	75%	90%	97%	66%	**87.24%**
5	Ind #2	Acq #2	94%	96%	95%	92%	61%	95%	93%	97%	76%	95%	89%	94%	92%	65%	**87.28%**
6	Ind #2	Acq #3	95%	85%	90%	88%	78%	84%	87%	97%	92%	95%	85%	92%	95%	70%	**87.76%**
7	Ind #3	Acq #1	76%	63%	75%	85%	72%	86%	77%	71%	75%	59%	77%	78%	80%	52%	**72.66%**
8	Ind #4	Acq #1	87%	94%	84%	84%	70%	84%	80%	79%	77%	55%	82%	67%	88%	52%	**76.34%**
9	Ind #5	Acq #1	88%	86%	76%	73%	73%	86%	76%	81%	75%	61%	62%	78%	84%	50%	**74.11%**
10	Ind #6	Acq #1	82%	84%	77%	83%	76%	75%	76%	86%	81%	73%	67%	73%	87%	50%	**75.79%**
11	Ind #7	Acq #1	80%	80%	76%	84%	77%	65%	79%	89%	88%	79%	77%	79%	87%	59%	**78.06%**
12	Ind #8	Acq #1	85%	86%	87%	83%	68%	76%	81%	92%	79%	69%	75%	86%	88%	55%	**78.64%**
13	Ind #9	Acq #1	86%	83%	89%	90%	75%	87%	77%	89%	81%	80%	79%	74%	87%	53%	**80.09%**

SUMMARY

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Results

Ind	*1*	Weight	0	0	1	1	2	0	1	1	1	1	2	0	0	0	1.1	1.2
Acq	*1*				Metacarpals				Proximal phalanges					Intermediate phalanges			Hand	Hand
Image	Individual	Acquisition	MC1	MC2	MC3	MC4	MC5	PP1	PP2	PP3	PP4	PP5	IP2	IP3	IP4	IP5	Score	Score
1	Ind #1	Acq #1			100%	100%	100%		100%	100%	100%	100%	100%				100.00%	96.66%
2	Ind #1	Acq #2			95%	89%	69%		90%	96%	95%	98%	96%				92.32%	100.00%
3	Ind #1	Acq #3			97%	90%	83%		93%	97%	97%	94%	69%				91.45%	97.18%
4	Ind #2	Acq #1			78%	59%	42%		86%	87%	94%	94%	88%				80.44%	84.31%
5	Ind #2	Acq #2			75%	59%	45%		81%	84%	91%	97%	69%				77.88%	83.82%
6	Ind #2	Acq #3			74%	56%	41%		85%	88%	93%	97%	96%				80.18%	87.46%
7	Ind #3	Acq #1			70%	50%	32%		61%	53%	59%	80%	41%				60.92%	73.87%
8	Ind #4	Acq #1			64%	58%	34%		71%	54%	68%	79%	40%				63.18%	75.90%
9	Ind #5	Acq #1			65%	55%	30%		54%	51%	60%	74%	19%				55.00%	71.02%
10	Ind #6	Acq #1			60%	56%	35%		51%	64%	67%	81%	23%				58.55%	76.12%
11	Ind #7	Acq #1			59%	52%	32%		70%	69%	69%	83%	42%				64.02%	80.33%
12	Ind #8	Acq #1			62%	53%	22%		71%	63%	59%	79%	28%				57.87%	77.47%
13	Ind #9	Acq #1			65%	62%	35%		61%	68%	68%	89%	42%				65.61%	81.38%

Ind	*2*	Weight	0	0	1	1	2	0	1	1	1	1	2	0	0	0	2.1	2.2
Acq	*1*				Metacarpals				Proximal phalanges					Intermediate phalanges			Hand	Hand
Image	Individual	Acquisition	MC1	MC2	MC3	MC4	MC5	PP1	PP2	PP3	PP4	PP5	IP2	IP3	IP4	IP5	Score	Score
1	Ind #1	Acq #1			84%	72%	42%		63%	81%	88%	96%	75%				77.95%	75.48%
2	Ind #1	Acq #2			80%	77%	69%		61%	81%	81%	97%	64%				79.78%	78.57%
3	Ind #1	Acq #3			96%	75%	81%		63%	82%	67%	91%	49%				78.48%	84.86%
4	Ind #2	Acq #1			100%	100%	100%		100%	100%	100%	100%	100%				100.00%	96.47%
5	Ind #2	Acq #2			98%	98%	98%		97%	96%	95%	97%	90%				96.87%	100.00%
6	Ind #2	Acq #3			93%	97%	98%		97%	96%	95%	99%	94%				96.87%	96.48%
7	Ind #3	Acq #1			89%	66%	58%		79%	69%	77%	93%	46%				75.50%	60.85%
8	Ind #4	Acq #1			71%	69%	55%		74%	71%	74%	93%	47%				73.40%	65.43%
9	Ind #5	Acq #1			87%	73%	56%		74%	68%	71%	93%	50%				75.33%	68.18%
10	Ind #6	Acq #1			92%	74%	92%		75%	70%	77%	93%	44%				79.75%	75.05%
11	Ind #7	Acq #1			92%	75%	85%		75%	69%	71%	94%	50%				79.43%	80.41%
12	Ind #8	Acq #1			86%	74%	74%		79%	74%	74%	93%	60%				80.46%	72.99%
13	Ind #9	Acq #1			88%	73%	67%		84%	75%	82%	95%	60%				81.39%	80.59%

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SUMMARY

Conclusion

- **Promising results**: Possible application as screening test for personal identification of unknown decedents when pathological and surgical features are not available

- In real case it may be hard to compare scans older than 30 years old
  - May not have **digital** X-rays scans

- Positioning of the hand should be controlled (2D projection of a 3D object)

- Improvements:
  - standard acquisition systems (same digital **quality** of X-rays scans)
  - **larger dataset** (>9 people)

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References

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