An automatic method for forensic identification based on soft computing techniques

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Outline

- Forensic identification by craniofacial superimposition
- Image registration
- Image registration, uncertainty and forensic identification = soft computing
- First stage: 3D skull model reconstruction using evolutionary algorithms
- Second stage: Skull-face overlay using evolutionary algorithms and fuzzy logic
- Concluding Remarks
Human identification (of alive or dead people) is one of the most outstanding tasks in forensic medicine.

Skeleton-based human identification (forensic anthropology)

Previous task to the selection of the candidates sample

- If anthropologists get enough information other techniques might be applied: fingerprint, autopsy, DNA
- Otherwise
1. Forensic identification by craniofacial superimposition

Forensic identification (II)
1. Forensic identification by craniofacial superimposition

Basis

- Craniofacial superimposition is a forensic process where photographs or video shots of a missing person are compared with “a model” of a skull that is found.

- Projecting one above the other (skull-face overlay) the anthropologist can try to determine whether that is the same person.

OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition

2. Image Registration (IR)

3. IR, Uncertainty and FI = Soft Computing

4. First stage: 3D skull model reconstruction

5. Second stage: Skull-face overlay

6. Conclusions
1. Forensic identification by craniofacial superimposition

Cranial and facial landmarks

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Craniometric landmarks

Cephalometric landmarks
1. Forensic identification by craniofacial superimposition

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**Landmarks correlation**
1. Forensic identification by craniofacial superimposition

Real case example

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1. Forensic identification by craniofacial superimposition

Methodology

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Identification {Positive/negative/likely positive/likely negative/indeterminate}
1. Forensic identification by craniofacial superimposition

History

- Methodological basis: Broca’s skull-face correspondence (1875), Bertillon’s accused physiognomic data collection (1986), and Martin and Saller’s anthropological measurements studies (1966) studies

- First documented case in 1880: identification of the skeletal remains of the poet Dante Alighieri

- The first identifications were based on photos: superimposition of the skull and face negatives and developing of the positive of the picture

- The next stage was the use of video superimposition, one of the most extended approaches nowadays

- Digital image processing has boomed the technique

- Recently used to identify the Indian tsunami victims and in terrorism. Other successful case studies: Josef Mengele and “Ivan the Terrible”
2. Image registration

Definition

Image registration (IR) aims to superimpose an image on a similar one considering the same coordinate system.

PROBLEM?

Images acquired in different coordinate systems

Unknown matching relationship between them
2. Image registration

Applications (I)

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- Surgery planning

- Image integration: multimodality, 3D/2D, etc.
2. Image registration

Applications (II)

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- Remote sensing

- 3D model reconstruction: CAD, archeology, forensic anthropology, etc.
2. Image registration

Problem statement (I)

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- IR aims to superimpose an image on a similar one considering the same coordinate system

- IR Components:
  - Scene \((I_s \subset \mathbb{R}^2/\mathbb{R}^3)\) and model \((I_m \subset \mathbb{R}^2/\mathbb{R}^3)\) images
  - Transformation \((f: \mathbb{R}^2/\mathbb{R}^3 \rightarrow \mathbb{R}^2/\mathbb{R}^3)\)
  - Similarity metric \((F)\)
  - Optimizer \((\text{search for the optimal } f)\)
2. Image registration

Problem statement (II)

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The problem statement is analogous to some other optimization problems which aim to find the best configuration among a set of choices:

\[ f^* = \arg \min_{f} \max_{F(I_s, I_m; f)} \quad \text{s.t.} \quad f^*(I_s) = I_m \]

Taxonomy of algorithms:

- **Exact**: find the optimal solution (NP-hard)
- **Approximate**: achieve solutions close to the optimal one in reasonable time

Classical IR methods stuck in local optima

Evolutionary Algorithms (EAs) have successfully tackled these situations
2. Image registration

Problem statement (IV)

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6. Conclusions

Search for the best f parameters (Optimization method) → Registration Error

Rotation = \{5°, 25°, 0°\}
Translation = \{2, 0, 1\}

\( f' \equiv f^* \) → f' Evaluation

For each model point, determine the closest point in the scene
Many forensic tasks require a 3D model of forensic objects (skulls, bones, corpses, etc.) that could be acquired using a 3D range scanner and a range IR (RIR) method.

The most advanced forensic labs use a 3D skull models to tackle the craniofacial superimposition technique.
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1. Photo and skull model development

2. Automatic skull-face overlay

3. Image processing and landmark location

4. 3D-2D IR: translation, rotation, scaling, and 2D projection

5. 3D model reconstruction

6. Decision making

Identification {Positive/negative/likely positive/likely negative/indeterminate}
3. IR, uncertainty and forensic identification = soft computing

Computer-based craniofacial superimposition: State of the art (I)

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Soft computing for forensic identification

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Manual skull-face overlay (very time consuming!)
3. IR, uncertainty and forensic identification = soft computing

Computer-based craniofacial superimposition: State of the art (III)

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Real case of manual craniofacial superimposition
There is a need of **automatic techniques** able to deal properly with incomplete information.

Uncertainty is inherent to landmark location, landmark matching, and to the identification decision.

Even so, the forensic **anthropologist** is not usually very skillful neither to calibrate the scanner nor to properly match the different views of the skull, some of them do not have a correspondence, etc.

**Manual craniofacial superimposition** is very time consuming.

**Degrees of confidence** in the identification result

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**OPPORTUNITY FOR SOFT COMPUTING !**
3. IR, uncertainty and forensic identification = soft computing

Research project to automate craniofacial superimposition

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ู่ Development of an automatic computer-based procedure to assist the forensic anthropologist in the identification task by craniofacial superimposition:

ู่ Design of automatic RIR methods to achieve accurate 3D models of forensic objects (using EAs)

ู่ Design of automatic 3D-2D IR methods to perform the skull-face overlay (using EAs and fuzzy sets)

ู่ Initial work supported by two granted projects (national and regional research calls)
3. IR, uncertainty and forensic identification = soft computing

Our computer-based craniofacial superimposition procedure

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Partial views acquisition

Preprocessing

3D Model

Yes

Skilled forensic?

No

3D Model (EA)

Skull and face landmarks location

Skull-face overlay (EA & FS)

Forensic validation of the overlay. Slight manual refinement if needed

Identification decision

Soft computing for forensic identification

Oscar Cordón
4. 3D skull model reconstruction using evolutionary algorithms

**Problem, requirements and tools**

- **OVERVIEW**
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**6. Conclusions**

- High complexity of the scenarios:
  - Accuracy-complexity trade-off: views acquired every 45° (8 per skull): small overlapping between adjacent views
  - Symmetries: multimodal search space
  - Huge data set (around 100,000 points in every view)
  - Rather often wrong acquisition of data even with rotary table and mainly without it

- An automatic and robust RIR method is required being able to deal with these scenarios and to achieve 3D models with a precision of millimeters in a reasonable time

- The flexibility of EAs, their good performance in other IR problems, and our previous experience in medical IR led us to consider these soft computing techniques
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**Coding scheme:** real-coded vector representing a rigid transformation with seven parameters

\[ \begin{align*}
\alpha & \quad \text{Axis}_x & \quad \text{Axis}_y & \quad \text{Axis}_z & \quad t_x & \quad t_y & \quad t_z \\
\end{align*} \]

Rotation

Translation

Partial reconstruction

Axis (\text{Axis}_x, \text{Axis}_y, \text{Axis}_z)
4. 3D skull model reconstruction using evolutionary algorithms

Evolutionary algorithm-based proposal (II)

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- **Coding scheme:** real-coded vector representing a rigid transformation with seven parameters

  \[
  \begin{align*}
  \alpha & \quad \text{Axis}_x \\
  \text{Axis}_y & \quad \text{Axis}_z \\
  t_x & \quad t_y & \quad t_z
  \end{align*}
  \]

- **Fitness function:**

  \[
  F(I_s, I_m; f) = MIN(MeanSE(I_m, f(I_s)))
  \]

  MSE is avoided because of the small overlapping between adjacent views

- **GCP and KD-Tree data structures are used to speed up the closest point computation**
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🌿 EA composition: Real-coding memetic algorithms.

Combination of:

🌿 3 advanced EAs as global search method: CHC, differential evolution, SS

🌿 3 different local search (LS) methods: Powell, SolisWets, XLS

🌿 Different LS application mechanisms and intensification-diversification trade-offs have been considered

🌿 Overall, the best evolutionary RIR method for 3D skull reconstruction is based on SS, XLS, a deterministic LS application, and the largest intensification level
4. 3D skull model reconstruction using evolutionary algorithms
Evolutionary algorithm-based proposal (IV)

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Good MA designs significantly improve both the basic EAs and the classical RIR methods based on sequential hybridizations:
4. 3D skull model reconstruction using evolutionary algorithms

Automatic skull feature extraction (I)

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- Range IR of the five frontal views of a skull acquired using the laser range scanner of the Physical Anthropology Lab of the University of Granada (*Konica-Minolta® VI-910*)

- Automatic extraction of invariant features to reduce dimensionality
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Data simplification (point reduction)

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</table>
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4. 3D skull model reconstruction using evolutionary algorithms

Results (II)

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6. Conclusions

- Reconstruction error: less than 1 mm
- 3D reconstruction time: 2 minutes
- Method robustness: low standard deviation in 30 different runs
5. Skull-face overlay using EAs and fuzzy sets
Problem issues, requirements and tools

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Again, very complex problem:

- The available photographs are provided by the family:
  - Not always good quality, neither good pose
  - Landmarks may be occluded
  - Camera data are unknown

- Uncertainty is inherent both to the landmark location and matching (the latter due to the flesh lack in the skull)

- Skull-face overlay is a very time consuming trial and error manual procedure

- Need of automatic techniques for skull-face overlay (3D-2D IR) being robust, fast, and able to deal with incomplete information

- We will exploit the suitability of EAs and FS to tackle the IR problem and to deal with the sources of uncertainty, respectively
5. Skull-face overlay using EAs and fuzzy sets

Considered methodology

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Search for the best superimposition (Evolutionary algorithm)

\[ f' \cong f^* \]

Rotation = \{60^\circ, (0,1,0)\}
Translation = \{2, 0, 1\}...

Registration error

Distance measuring between every pair of landmarks

\[ f' \text{ evaluation} \]
5. Skull-face overlay using EAs and fuzzy sets

Our proposal

- Evolutionary 3D skull-2D face IR problem with a complex registration transformation: translation, rotation, scaling, and projection. Twelve parameters

- Real-coding scheme, better suited for IR

- Advanced EAs: elitist GA, binary tournament, BLX-α/SBX crossovers, random mutation. CMA-ES, SS, multimodal GAs, co-evolutionary approaches, …

- Realistic conditions: Variable number of landmarks according to the photograph and the skull conditions. Robustness under multiple runs to allow a single run

- Fitness function: mean of the distances between the facial and the projected cranial landmarks (mean error, ME)
5. Skull-face overlay using EAs and fuzzy sets
New proposal: registration transformation (I)

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- The final solution to the skull-face overlay problem should be the transformation making the 3D skull model become accurately located in the same pose of the missing person in the photo.

- There are two important moments to be considered:

  - Replicating the scenario where the photograph was acquired is rather complex because of the number of unknowns involved in the process (even more than camera calibration in CV).
5. Skull-face overlay using EAs and fuzzy sets

New proposal: registration transformation (II)

- The registration transformation to be estimated includes a rotation (R), a scaling (S), a translation (T), and a perspective projection (P).

- Given two sets of 2D facial and 3D cranial landmarks:

$$F = \begin{bmatrix} x_{f_1} & y_{f_1} & 1 & 1 \\ x_{f_2} & y_{f_2} & 1 & 1 \\ \vdots & \vdots & \vdots & \vdots \\ x_{f_N} & y_{f_N} & 1 & 1 \end{bmatrix}, \quad C = \begin{bmatrix} x_{c_1} & y_{c_1} & z_{c_1} & 1 \\ x_{c_2} & y_{c_2} & z_{c_2} & 1 \\ \vdots & \vdots & \vdots & \vdots \\ x_{c_N} & y_{c_N} & z_{c_N} & 1 \end{bmatrix}$$

The aim is to solve an over-determined system of equations with 12 unknowns \((r_x, r_y, r_z, d_x, d_y, d_z, \theta, s, t_x, t_y, t_z, \phi)\):

$$F = f(C) = C \cdot R \cdot S \cdot T \cdot P$$

where: 

$$R = (A \cdot D_1 \cdot D_2 \cdot \Theta \cdot D_2^{-1} \cdot D_1^{-1} \cdot A^{-1})$$
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6. Conclusions

- Projective transformations are hard to be estimated. Cameras use them to provide a realistic picture of the scene from the observer’s viewpoint.

- In computer graphics, the pinhole camera is modeled using a frustum given by the near clipping plane (NCP) and the far clipping plane (FCP):

- The frustum determines the visible region.
5. Skull-face overlay using EAs and fuzzy sets

New proposal: registration transformation (IV)

Thus, our coding scheme is a vector of 12 real values:

\[
\begin{array}{cccccccccccc}
& r_x & r_y & r_z & d_x & d_y & d_z & \theta & s & t_x & t_y & t_z & \phi \\
\end{array}
\]

ranging in the following intervals:

\[
\begin{align*}
    r_i & \in [\text{Centroid} - \text{radius}, \text{Centroid} + \text{radius}], \quad i \in \{x, y, z\} \\
    d_i & \in [-1, 1], \quad i \in \{x, y, z\} \\
    \theta & \in [0^\circ, 360^\circ] \\
    s & \in [0.25, 2] \\
    \phi & \in [10^\circ, 150^\circ] \\
    t_x & \in [-\text{length}_{FB} - (C_x + \text{radius}), \text{length}_{FB} - (C_x - \text{radius})] \\
    t_y & \in [-\text{length}_{FB} - (C_y + \text{radius}), \text{length}_{FB} - (C_y - \text{radius})] \\
    t_z & \in [\text{NCP} - (C_z + \text{radius}), \text{FCP} - (C_z - \text{radius})]
\end{align*}
\]

where:

\[
\begin{align*}
    \text{radius} &= \max(||\text{Centroid} - C_j||) \\
    \text{FB} &= \text{the frustum Base} \\
    \text{length}_{FB} &= \frac{(\min_{FD} + \text{FCP}) \cdot \sin \left(\frac{\theta_{\max}}{2}\right)}{\sin (90^\circ - (\frac{\theta_{\max}}{2}))} \\
    \text{min}_{FD} &= \frac{1}{\tan \left(\frac{\theta_{\max}}{2}\right)}
\end{align*}
\]
Two different sources of uncertainty:

1. **Inherent uncertainty associated with the two different objects under study (a skull and a face):**
   - **Landmark location:** Every forensic expert is prone to locate the landmarks in a slightly different place.
   - **Landmark matching:** Partial matching of the two landmark sets (cephalometric and craniometric).

5. **Second stage:** Skull-face overlay
2. **Uncertainty associated with the 3D skull-2D photo overlay process:**

- **Landmark location:** Difficulty to select a good (cephalometric) landmark set due to the photo conditions:
  - face pose, partial occlusions, and poor image quality
  - Forensic anthropologists are prone to locate only those landmarks which can be unquestionably identified!

- **Landmark matching:** The selected reduced landmark set is usually coplanar or near-coplanar:
  - the equation system becomes undetermined and the 3D-2D IR process gets inaccurate results
  - The preferred photos by the forensic anthropologists are usually those with a frontal pose!
5. Skull-face overlay using EAs and fuzzy sets
Fuzzy landmarks to jointly tackle location and coplanarity problems (I)

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- Each cephalometric landmark is a fuzzy point defined by a bi-dimensional fuzzy set. The higher the uncertainty related to a landmark → the broader the fuzzy region

- Solution for the two landmark location problems:
  - The inherent difficulty to locate the landmark in the right place
  - The complexity of locating a significant and unquestionable number of landmarks in a photo

- Thanks to the flexibility given to the forensic expert, (s)he is able to mark a larger number of landmarks located in different planes, thus also solving the coplanarity problem
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There is a mask with the membership degree of each pixel to the fuzzy point associated to every landmark

Need of a new fitness function considering a distance between crisp and fuzzy points
5. Skull-face overlay using EAs and fuzzy sets
Fuzzy landmarks to jointly tackle location and coplanarity problems (III)

OASerview

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- **α-cuts** to calculate the distance from a crisp point (projected craniometric landmark) to a fuzzy point (cephalometric landmark)

- Crisp-fuzzy distance and new fitness function:

\[
d^*(x, \tilde{F}) = \frac{\sum_{i=1}^{m} d_i \cdot \alpha_i}{\sum_{i=1}^{m} \alpha_i}
\]

\[
fuzzy\ ME = \frac{\sum_{i=1}^{N} d^*(f(cl^i), \tilde{F}^i)}{N}
\]
5. Skull-face overlay using EAs and fuzzy sets

Experiments (I)

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Experimental design:

- **Target**: compare manual vs. automatic SFO results using either near-coplanar crisp or fuzzy cephalometric landmarks

- **Robustness analysis**: accuracy dispersion in 30 different runs

- **Real identification cases**: previously solved by the Physical Anthropology Lab at the UGR for the Spanish scientific police

- **ME is not valid**: (two different landmark sets)!

- **Qualitative analysis**: visual comparison of the overlay results by the forensic anthropologists

- **Quantitative analysis**: percentage of the head boundary not covered by the projected skull boundary (manually defined by the forensic experts)
5. Skull-face overlay using EAs and fuzzy sets
Experiments (II)

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Area Deviation Error:

It is not a perfect measure (no information on accuracy of the inner skull parts fitting) but at least it is objective (and complementary)!
5. Skull-face overlay using EAs and fuzzy sets

Results: Malaga case study

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3. IR, Uncertainty and FI = Soft Computing

4. First stage: 3D skull model reconstruction

5. Second stage: Skull-face overlay

6. Conclusions

Malaga case study: Overlays comparison

- Manual
- CMA-ES (6 landmarks)
- Fuzzy CMA-ES (15 landmarks)

<table>
<thead>
<tr>
<th>Method</th>
<th>Area deviation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>34.70%</td>
<td>several hours</td>
</tr>
<tr>
<td>CMA-ES (6)</td>
<td>28.73%</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Fuzzy CMA-ES (15)</td>
<td>13.23%</td>
<td>2-4 minutes</td>
</tr>
</tbody>
</table>
5. Skull-face overlay using EAs and fuzzy sets

Results: Cádiz case study (I)

Cádiz case study, pose 1: Overlays comparison

- **Manual**
  - Area deviation error: 32.64%
  - Several hours

- **CMA-ES (8 landmarks)**
  - Area deviation error: 18.22%
  - 18 seconds

- **Fuzzy CMA-ES (10 landmarks)**
  - Area deviation error: 15.84%
  - 2-4 minutes

OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition
2. Image Registration (IR)
3. IR, Uncertainty and FI = Soft Computing
4. First stage: 3D skull model reconstruction
5. Second stage: Skull-face overlay
6. Conclusions
5. Skull-face overlay using EAs and fuzzy sets

Results: Cádiz case study (II)

OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition
2. Image Registration (IR)
3. IR, Uncertainty and FI = Soft Computing
4. First stage: 3D skull model reconstruction
5. Second stage: Skull-face overlay
6. Conclusions

Cádiz case study, pose 2: Overlays comparison

- Manual
- CMA-ES (9 landmarks)
- Fuzzy CMA-ES (14 landmarks)

<table>
<thead>
<tr>
<th>Method</th>
<th>Area deviation error</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>31.58%</td>
<td>several hours</td>
</tr>
<tr>
<td>CMA-ES</td>
<td>50.28%</td>
<td>18 seconds</td>
</tr>
<tr>
<td>Fuzzy CMA-ES</td>
<td>27.96%</td>
<td>2-4 minutes</td>
</tr>
</tbody>
</table>
5. Skull-face overlay using EAs and fuzzy sets

Results: Cádiz case study (III)

**OVERVIEW**

1. Forensic identification (FI) by craniofacial superimposition
2. Image Registration (IR)
3. IR, Uncertainty and FI = Soft Computing
4. First stage: 3D skull model reconstruction
5. Second stage: Skull-face overlay
6. Conclusions

- Cádiz case study, pose 3: Overlays comparison

<table>
<thead>
<tr>
<th>Method</th>
<th>Manual</th>
<th>CMA-ES (11 landmarks)</th>
<th>Fuzzy CMA-ES (16 landmarks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area deviation</td>
<td>31.84%</td>
<td>42.84%</td>
<td>21.26%</td>
</tr>
<tr>
<td>Time</td>
<td>several hours</td>
<td>18 seconds</td>
<td>2-4 minutes</td>
</tr>
</tbody>
</table>

Soft computing for forensic identification

Oscar Cordón
5. Skull-face overlay using EAs and fuzzy sets

Results: Cádiz case study (IV)

OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition
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3. IR, Uncertainty and FI = Soft Computing
4. First stage: 3D skull model reconstruction
5. Second stage: Skull-face overlay
6. Conclusions

Cádiz case study, pose 4: Overlays comparison

- Manual
- CMA-ES (12 landmarks)
- Fuzzy CMA-ES (15 landmarks)

Area deviation error:
- Manual: 38.22%
- CMA-ES: 53.85%
- Fuzzy CMA-ES: 18.95%

Time:
- Manual: several hours
- CMA-ES: 18 seconds
- Fuzzy CMA-ES: 2-4 minutes
Very complex real case.
Cádiz (Spain). Single, low quality, passport photo:

6 crisp landmarks
16 fuzzy landmarks
OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition
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4. First stage: 3D skull model reconstruction
5. Second stage: Skull-face overlay
6. Conclusions

5. Skull-face overlay using EAs and fuzzy sets

Results: Morocco case study (II)

Morocco case study: Overlays comparison

- Manual
- CMA-ES (6 landmarks)
- Fuzzy CMA-ES (16 landmarks)

Area deviation error:
- Manual: 31.73% after several hours
- CMA-ES: 32.63% in 15 seconds
- Fuzzy CMA-ES: 11.92% in 2-4 minutes
5. Skull-face overlay using EAs and fuzzy sets

Results: Example runs

Fuzzy CMA-ES example runs:
5. Skull-face overlay using EAs and fuzzy sets

Results: Granada case study

OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition
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3. IR, Uncertainty and FI = Soft Computing
4. First stage: 3D skull model reconstruction
5. Second stage: Skull-face overlay
6. Conclusions

Another real case (Granada, Spain):

- Manual superimposition
- Fuzzy CMA-ES superimposition

Area deviation error:

- Manual superimposition: 13.81%
- Fuzzy CMA-ES superimposition: 4.73%

**several hours**  **2-4 minutes**
5. Skull-face overlay using EAs and fuzzy sets

Results: Alhambra case study (I)

**OVERVIEW**

1. Forensic identification (FI) by craniofacial superimposition

2. Image Registration (IR)

3. IR, Uncertainty and FI = Soft Computing

4. First stage: 3D skull model reconstruction

5. Second stage: Skull-face overlay

6. Conclusions

- Last real case (Alhambra surroundings, Granada, Spain):
  First use of our method for a Spanish police identification!

**Manual superimposition**

**Fuzzy CMA-ES superimposition**

Area deviation error: 28.26%

Area deviation error: 21.79%

**several hours**

**2-4 minutes**
5. Skull-face overlay using EAs and fuzzy sets

Results: Alhambra case study (II)

OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition

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3. IR, Uncertainty and FI = Soft Computing

4. First stage: 3D skull model reconstruction

5. Second stage: Skull-face overlay

6. Conclusions

❖ Last real case (second photograph):

Manual superimposition

Fuzzy CMA-ES superimposition

Area deviation error:

37.54%

Area deviation error:

21.04%

several hours

2-4 minutes

Soft computing for forensic identification

Oscar Cordón
5. Skull-face overlay using EAs and fuzzy sets

Results: Negative cases (I)

OVERVIEW

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4. First stage: 3D skull model reconstruction

5. Second stage: Skull-face overlay

6. Conclusions

Skull-face overlay is independent of the decision making stage and our method must get the best possible overlay regardless whether the identification is positive or not:

Best overlay (30 runs)

Worst overlay (30 runs)
5. Skull-face overlay using EAs and fuzzy sets

Results: Negative cases (II)

OVERVIEW

1. Forensic identification (FI) by craniofacial superimposition

2. Image Registration (IR)

3. IR, Uncertainty and FI = Soft Computing

4. First stage: 3D skull model reconstruction

5. Second stage: Skull-face overlay

6. Conclusions

Best overlay (30 runs)

Worst overlay (30 runs)
5. Skull-face overlay using EAs and fuzzy sets

Results: Negative cases (III)

OVERVIEW

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2. Image Registration (IR)

3. IR, Uncertainty and FI = Soft Computing

4. First stage: 3D skull model reconstruction

5. Second stage: Skull-face overlay

6. Conclusions

Best overlay (30 runs)

Worst overlay (30 runs)
5. Skull-face overlay using EAs and fuzzy sets

Results: Negative cases (IV)

OVERVIEW

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6. Conclusions
6. Conclusions

- We have successfully tackled the automation of the forensic identification by craniofacial superimposition in order to assist the forensic anthropologist.

- Soft Computing is suitable for this task given the intrinsic characteristics of this identification technique.

- Our method has been used in the identification of a real-world case for the Spanish Scientific Police (Guardia Civil).

- A web site has been developed for the project: [www.softcomputing.es/socovifi](http://www.softcomputing.es/socovifi)
6. Conclusions
Future works

Improve the automatic soft computing-based SFO method developed to make it more reliable and customizable to different forensic scenarios:

- A web-based poll is being developed with forensic experts to estimate the landmark location variability
- New fuzzy distances will be considered
- The uncertainty in landmark matching will be shortly tackled
- Objective and semi-automatic SFO validation techniques will be developed (based on anthropometric aspects & computer vision)
- We aim to properly model old-fashioned cameras to tackle identification cases related to the Spain’s civil war
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Research Projects:

- Two Spanish Research Plan projects: SOCOVIFI (2006-09) and SIMMRA (2010-12)
- An Andalusian Government Research project (2007-10)

Technology Transfer:

- An international PCT patent was approved by the European Agency in February, 2011
- It will be commercialized in Mexico in 2012
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Obtained results (II): Software package
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6. Conclusions

PhD Dissertations:


International Awards:

- IFSA Award for Outstanding Applications of Fuzzy Technology. 2011
- EUSFLAT Best Ph.D. Thesis Award. 2011. Author: Dr. Oscar Ibáñez. Advisors: Drs. Cordón and Damas
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6. Conclusions

Main publications


Soft computing for forensic identification

Oscar Cordón
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Thank you for your attention

Questions ?