UNIVERSIDAD DE JAÉN

European Centre for Soft Computing

UNIVERSIDAD DE GRANADA

SOFT COMPUTING AND COMPUTER VISION FOR FORENSIC IDENTIFICATION

Forensic identification

Human identification (of alive or dead people) is one of the most outstanding research areas in forensic medicine

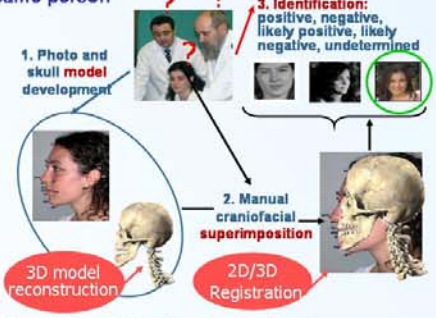
Skeleton-based human identification (Forensic Anthropology)

Previous task to select our candidates

If anthropologists get enough information other techniques might be applied: fingerprint, autopsy, DNA.
Otherwise

Photographic supra-projection

Photographic supra-projection is a forensic process where photographs or video shots of a missing person are compared with "a model" of a skull that is found in order to determine whether that is the same person



Our main objective is to develop an automatic system to assist the forensic anthropologist in the identification of a missing person by means of photographic supra-projection technique.

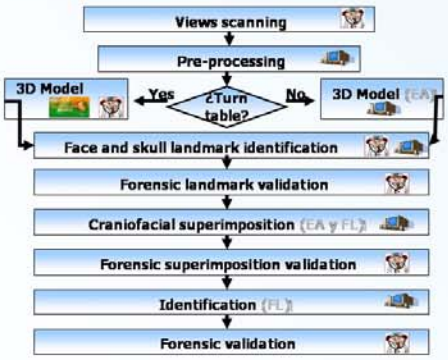
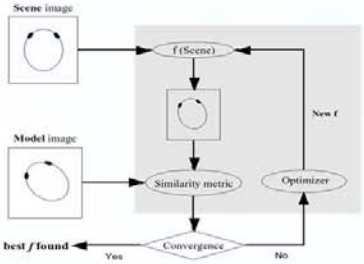


Image registration

Image Registration (IR): is the process of overlapping (from a different coordinate system to a common one) two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors.

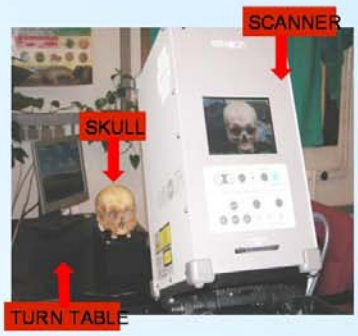


3D skull reconstruction

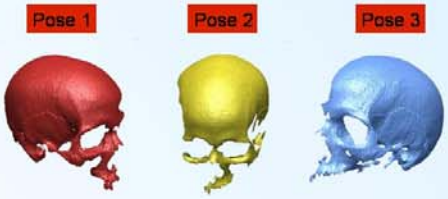
3D skull reconstruction is the first stage of the photographic supra-projection process where a virtual/digital 3D model of the skull is obtained.

The reconstruction procedure concerns the following steps:

• First, experts make use of 3D image acquisition devices. Laser range scanners are the more common ones due to their easy portability and inexpensive price.



The whole object cannot be often completely scanned with a single image. Multiple scans from different views are required to build a 3D model. The turn table is another device that aids the expert to give different poses of the skull to the scanner each time a new range image is taken.



• Second, image processing tools are used for smoothing of the images and for extracting relevant image features, for instance, crest line points.

• Third, IR methods are used for the accurate integration of all the acquired and post-processed range images. Evolutionary algorithms (EAs) have demonstrated their more suitable applicability to IR problems for tackling the 3D skull reconstruction procedure.

3D skull reconstruction with EA-based IR methods

Craniofacial superimposition (CS)

The registration transformation to estimate includes rotation (R), scaling (S), translation (T) and projection (P). Given the two sets of cephalometric 2D (F) and craniometric 3D (C) 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 goal is to solve a indeterminate equation system with twelve un$(r_x, r_y, r_z, d_x, d_y, d_z, \theta, s, t_x, t_y, t_z, \phi)$

$$F = C \cdot (A \cdot D_1 \cdot D_2 \cdot \theta \cdot D_2^{-1} \cdot D_1^{-1} \cdot A^{-1}) \cdot S \cdot T \cdot P$$

where: $R = (A \cdot D_1 \cdot D_2 \cdot \Theta \cdot D_2^{-1} \cdot D_1^{-1} \cdot A^{-1})$

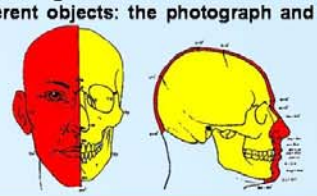
Fuzzy Logic in CS

Sources of uncertainty (modeled by Fuzzy Logic):
Location uncertainty

- Every forensic anthropologist is prone to locate the landmarks in a slightly different place
- Variation in shade distribution depending on light condition during photographing, unsuitable camera focusing, poor image quality, etc.

Matching uncertainty

- Partial matching situation
- Two different objects: the photograph and the skull



Evolutionary Algorithms in CS

Different Evolutionary Algorithms have been applied to tackle craniofacial superimposition: Genetic Algorithms, Scatter Search, and Covariance Matrix Adaption Evolution Strategy.

Manual superimposition (up to 24 hours)

CMA-ES and Fuzzy Location superimposition (90 seconds)

Manual superimposition (up to 24 hours)

CMA-ES superimposition (15 seconds)

Future work

Introduce the already said matching uncertainty and the location uncertainty of craniometric landmarks.
Tackle the third identification stage to assist the forensic expert to take the final identification decision.

Research team

The multidisciplinary research team involved in he project comprises the Applications of Fuzzy Logic and Evolutionary Algorithm research unit at the European Centre for Soft Computing, the Physical Anthropology Lab at the University of Granada, and the Department of Computer Science at University of Jaén.