Using Novel 3D Comparative Techniques to Assess Skeletal Remains

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INTREPID Forensics — Interdisciplinary Training and Research Programme for Innovative Doctorates in Forensic Science

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Identification of Skeletal Remains

Assessment Methods

- Age, sex, & ancestry of the skeleton are assessed to create a biological profile of the deceased
- Morphological (shape/feature-based) & metric techniques exist
  - ➢ Interobserver error persists in both even in trained osteologists (Adams & Byrd, 2002)
- Computerized methods have been developed to improve the objectivity of skeletal assessment methods for identification
  - ➢ Tend to focus on either morphological or metric analyses

This project will create a new computerized method of assessing sex & ancestry while combining morphological & metric methods

The Skull

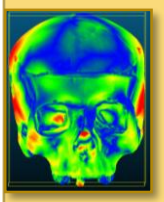
- Differences between males & females exist in the features of the skull
- The degree of difference (sexual dimorphism) varies within different populations

Source: Missing Tooth Investigators

Skulls from different geographic populations will be included in this study in order to represent a range of sexual dimorphism

The Power of 3D Data Analyses

Holistic Shape-Based Analyses



Compares a sample to an idealized 3D model to determine the acceptable amount of variation within a category. Samples exhibiting marked variation can be used to create new categories.

Limitations:
- The use of a single reference model does not adequately capture natural variation
- Statistical analyses cannot be applied

Geometric Morphometrics (GMM)

Craniometric points are recorded; creates an abstract, but statistically significant, shape to which samples can be compared

Limitations:
- Cannot account for external variation
- Cannot be used on samples that are not represented in the reference database

Scan me!

Interactive example of a 3D cranium (low-quality)


Source: Ross et al., 2010

By creating a method that combines shape-based & GMM analyses, the limitations of each method can be mitigated by the other

Using 3D Data to Create A New Method of Skeletal Assessment

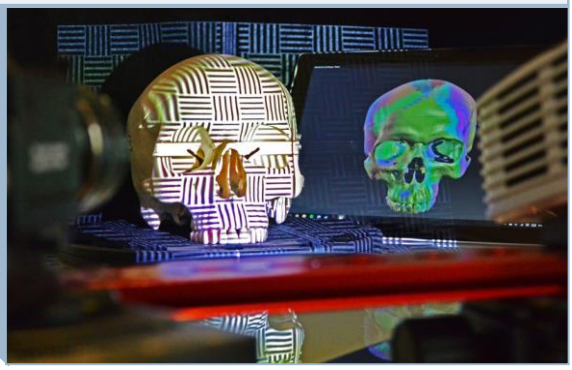
Reference 3D Ground-Truth Database

Used to create & test the accuracy of the computerized assessment method

Documented Skeletal Collections:
- ✓ British population (St. Bride's Fleet Street, U.K.)
- ✓ Asian population (Nagasaki University School of Medicine, Japan)

To Be Documented/Confirmed:
- Mediterranean population (Greece / Italy)
- North American population (U.S.A.)
- South African population (Pretoria)

Detailed & scaled 3D models are produced with a structured light scanner, which uses a series of light patterns to determine the external surface of objects



Creating the Computer Program

Compares a sample to those in the reference database to:
- Perform holistic shape-based analyses to identify areas/features of significant difference
- Perform unsupervised cranial landmark selection to determine which points should be included in the analyses

Results in a method that takes advantage of all the data in 3D models

Testing the Computer Program

- 20% holdout sample → to be used to test the accuracy of the program
- Both the holistic & point-based analyses will be refined → iterative process

The highest achievable accuracy will be determined after constant refinement

References

Adams, B. J. and Byrd, J. E. (2002). Interobserver variation of selected postcranial skeletal measurements. *Journal of Forensic Sciences*, 47:1193–1202.

Ross, A. H., Slice, D. E., and Williams, S. E. (2010). Geometric morphometric tools for the classification of human skulls. Technical report, U.S. Department of Justice. Document No. 231195.

Additional Information

To learn more about this project & the INTREPID Forensics programme, visit: http://www.intrepid-forensics.eu/project-9

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