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Introduction

Facial approximation aims are to:

- Estimate the antemortem facial appearance from unknown skeletal remains
- Suggest the identity of persons to whom the remains might belong
- Capture public attention regarding the case (SWGANTH definition [1])

Goal of the study → Ensure an accurate estimation of the face

Material

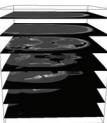
500 CT-scans collected in French hospitals
 (subjects with pathology or trauma excluded)

Sex: 481 males / 407 females
 Age: 18 to 96 years old, homogeneously distributed
 (mean = 50.2 yrs; sd = 19.5 yrs)

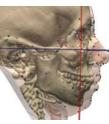
Facial approximation method elaboration

All operations performed with TIVMI [2]

A – Patient's surfaces reconstruction using the **HMH 3D** algorithm [3,4]

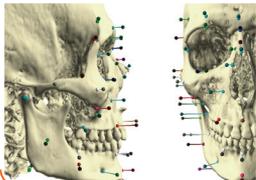



B – Positioning of **222 landmarks** (59 on bone & 60 on skin surfaces) using reference planes (repeatability & reproducibility tested)

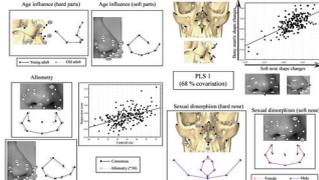



C – Analyses

Extraction of distances → **Soft tissue depth (STD) study** (age, sex & corpulence)



Extraction of 3D coordinates → **Geometric morphometrics (MorphoJ [5])**



D – Estimation of skin landmarks position

Estimation of STD with regression formulae using craniometrics, age, sex & corpulence as independent variables (following [6,7])



Estimation of eyes, nose, mouth & ears shape independently after Procrustes superimpositions: *regressions of shape patterns based on Principal Component scores of highly covarying osseous and cutaneous configurations*

= 3D coordinates of 100 estimated skin landmarks

AFA3D module in TIVMI

Anthropological Facial Approximation in 3D (AFA3D)

1 – Placement of 78 bony landmarks

Directly on 3D skull surface :
 - HMH3D reconstruction in TIVMI (or import laser-scanned surface) (or digitise landmarks and import list)

| Name | Status |
|------------------|--------|
| Orbitale (right) | ✓ |
| Orbitale (left) | ✓ |
| Nasion | ✓ |
| Archioc | ✗ |
| Pronasion | ✗ |
| Mid-nasale | ✗ |

2 – Indicate the biological factors

Sex
 Age
 Corpulence
 (can be left unknown)



3 – Automatic estimation of the 100 skin landmarks (R [8] routine)

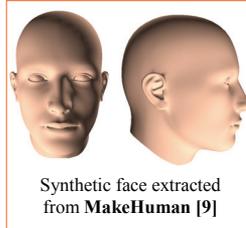
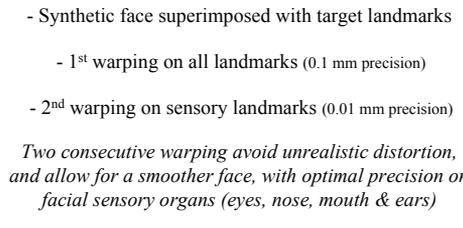
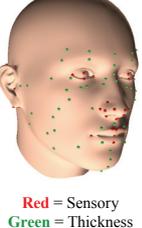
4 – Warping of a synthetic face to the target approximation

- Synthetic face superimposed with target landmarks

- 1st warping on all landmarks (0.1 mm precision)

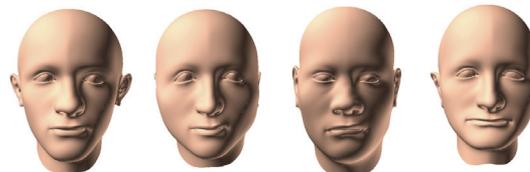
- 2nd warping on sensory landmarks (0.01 mm precision)

Two consecutive warping avoid unrealistic distortion, and allow for a smoother face, with optimal precision on facial sensory organs (eyes, nose, mouth & ears)

Red = Sensory
 Green = Thickness

Warping examples



An important variability can be obtained through the warping of the same synthetic face, following specific target skin landmarks

5 – Individualisation of the approximated face

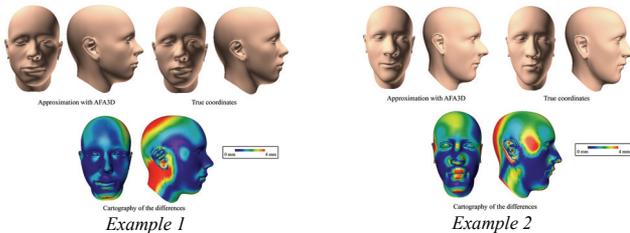
Custom changes of :
 Skin colour; eyes colour; lips colour; hairstyle and colour (still in development)



+ Possibility to export the mesh in 3D graphics software for customisation

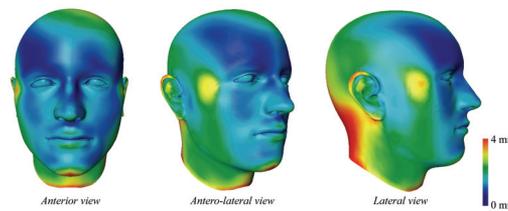
Uncertainty of the approximations

Warping following the "true" skin landmarks coordinates versus AFA3D facial approximation (cartographies with SurfaceDistance in Amira [10])



Example 1

Example 2



Cartography of the mean differences (based on 17 individuals)

Perspectives

- Enhance :
 - The referential sample
 - The estimation methods
 - The individualisation options
- Test AFA3D with other groups, and compare approximations with photographs of the subjects

References

- [1] The Scientific Working Group for Forensic Anthropology (SWGANTH, <http://www.swganth.org/>).
- [2] TIVMI (Treatment and Increased Vision for Medical Imaging), developed by B. Dutailly. Free download at <http://www.pacea.u-bordeaux1.fr/TIVMI/>
- [3] Spoor, C.F., Zonneveld, F.W. & Macho, G.A. (1993). Linear measurements of cortical bone and dental enamel by computed tomography: applications and problems. *American Journal of Physical Anthropology*, Vol. 91, No. 4, pp. 469-484.
- [4] Dutailly, B., Coquegniot, H., Desbarats, P., Gueorguieva, S. & Synave, R. (2009). 3D surface reconstruction using HMH algorithm. In *IEEE International Conference on Image Processing (ICIP09)*, pp. 2505-2508.
- [5] Klingenberg, C.P. (2010). MorphoJ: an integrated software package for geometric morphometrics. *Molecular Ecology Resources*, Vol. 11, No. 2, pp. 353-357.
- [6] Simpson, E. & Henneberg, M. (2002). Variation in soft-tissue thicknesses on the human face and their relation to craniometric dimensions. *American Journal of Physical Anthropology*, Vol. 118, No. 2, pp. 121-133.
- [7] Codinha, S. (2010). Facing the dead - Prediction of facial soft tissue depths from craniometric dimensions for forensic craniofacial identification. In *Departamento de Ciencias da Vida*. Coimbra: Universidade de Coimbra, 248 p.
- [8] R Development Core Team (2010). *R: A language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing.
- [9] MakeHuman software (<http://www.makehuman.org/>), for the humanoid mesh, see: <http://sites.google.com/site/makehumandocs/the-humanoid-mesh>.
- [10] AMIRA, Mercury computer systems, Berlin, Germany.

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