

# Virtuality, a tool to go further inside reality

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## Introduction

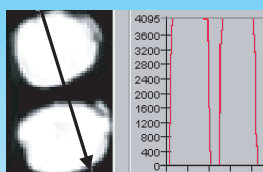
The invention of the CT scan (Hounfield & Cormak; end of the sixties) made a revolution in the field of paleanthropological research. Spreading of prototyping tooling opens us new perspectives.

We present here the three steps needed to obtain the reconstructed object.

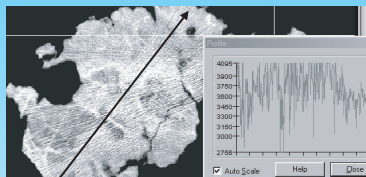
## Step one: Data acquisition

Living and fossil bones do not respond to x-rays the same way, due to their internal characteristics:

Two kinds of problems:



Sangiran 27 teeth longitudinal cut: densities overpassing the superior limit of the Hounsfield scale.



Lack of detector signal causing high noise levels on a sagittal cut of Sangiran 27

**Solution** → Recalibrate the CT scan  
Difficult, especially in medical environment

**Solution** → Use larger slice  
This will enhance the artefact of partial volum. Find the best cut size for having the fewest artefacts

### Living Structures

Low and homogenous mineralization  
High quantity of water

### Fossilized Bones

High and heterogenous mineralization  
Absence of water

## Step two: Data treatment



Figure 1: Down reconstruction with global thresholding; Up reconstruction with the SMM protocol.

Internal characteristics of fossils forbid global thresholding, as all medical software propose it, to get precise and accurate 3D reconstructions. The solution is the SMM (Multiple Manual Threshold) protocol, based on HMH (Spoor *et al.*, 1993) which consists to define precisely the outline of the object section by section depending on variations of mineralization (Figure 1).

Figure 2b: Clavicle with heavy bony structures (Yellow) and low bony structures (Blue) viewed by transparency.

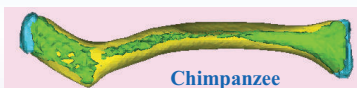
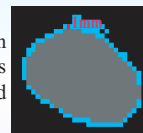


Figure 2a: Transversal cut section of a clavicle; grey: outline obtained by HMH; blue: overestimated outline by global thresholding.



- With global threshold the outline, on each slice, becomes larger (figure 2a) and thus the final calculated volum is not accurate. The increases of volum can reach 10%.
- We have to be careful when we want to compare endocranium (Figure 3) or bony structures (Figure 2b) volum ...

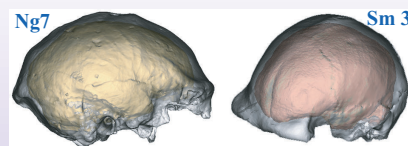


Figure 3: Nangdong 7 and Sambungmacan 3 cranium and endo-cranium viewed by transparency

## Step three: Prototyping tooling

- Prototyping allows:
  - to obtain a real object from its numerical data (Figure 4)
  - to observe structures that was previously impossible to study, like the endocast of a skull filled with sediments (Figure 5)
- We use Selective Laser Sintering (SLS) : it is a plastic powder bind by a laser.

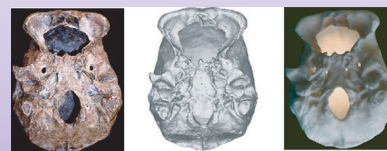


Figure 4: Nangdong 12 from left to right: original, 3D virtual reconstruction and prototyping tooling

## Conclusion

- From the original remains to the prototype, there are three steps (Figure 5) and each gives paleoanthropological information that was previously impossible to study. These technics are very helpful to understand our history, but their limits have to be well known.

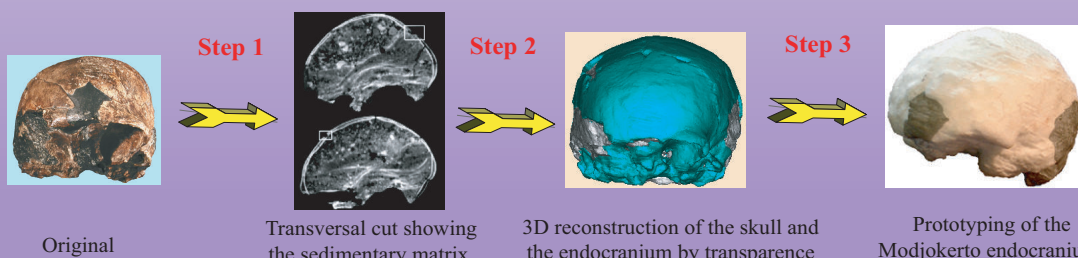


Figure 5: Summary of the three steps with the Modjokerto child from the original remains to the prototype

### Bibliography

F. Spoor, F. Zonneveld, G. Macho, Linear measurements of cortical bone and dental enamel by CT: applications and problems, *Am. J. Phys. Anthropol.* 91 (1993) 469-484.