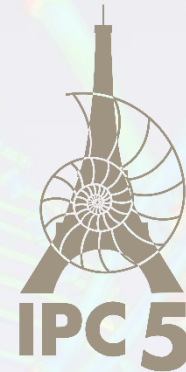


# MorphoDig, an open-source 3d freeware dedicated to biology

Institut des Sciences de l'Evolution  
Université de Montpellier, France

[renaud.lebrun@umontpellier.fr](mailto:renaud.lebrun@umontpellier.fr)



UNIVERSITE  
DE MONTPELLIER

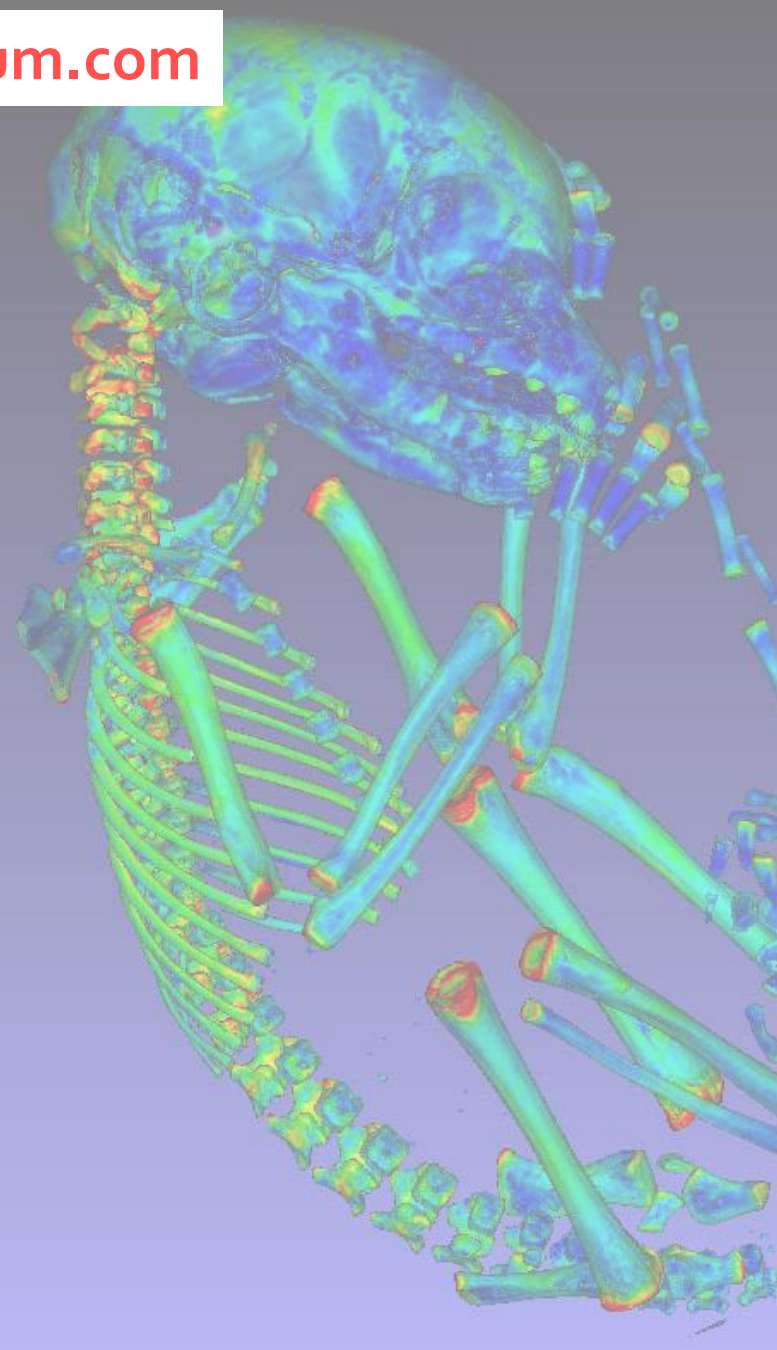
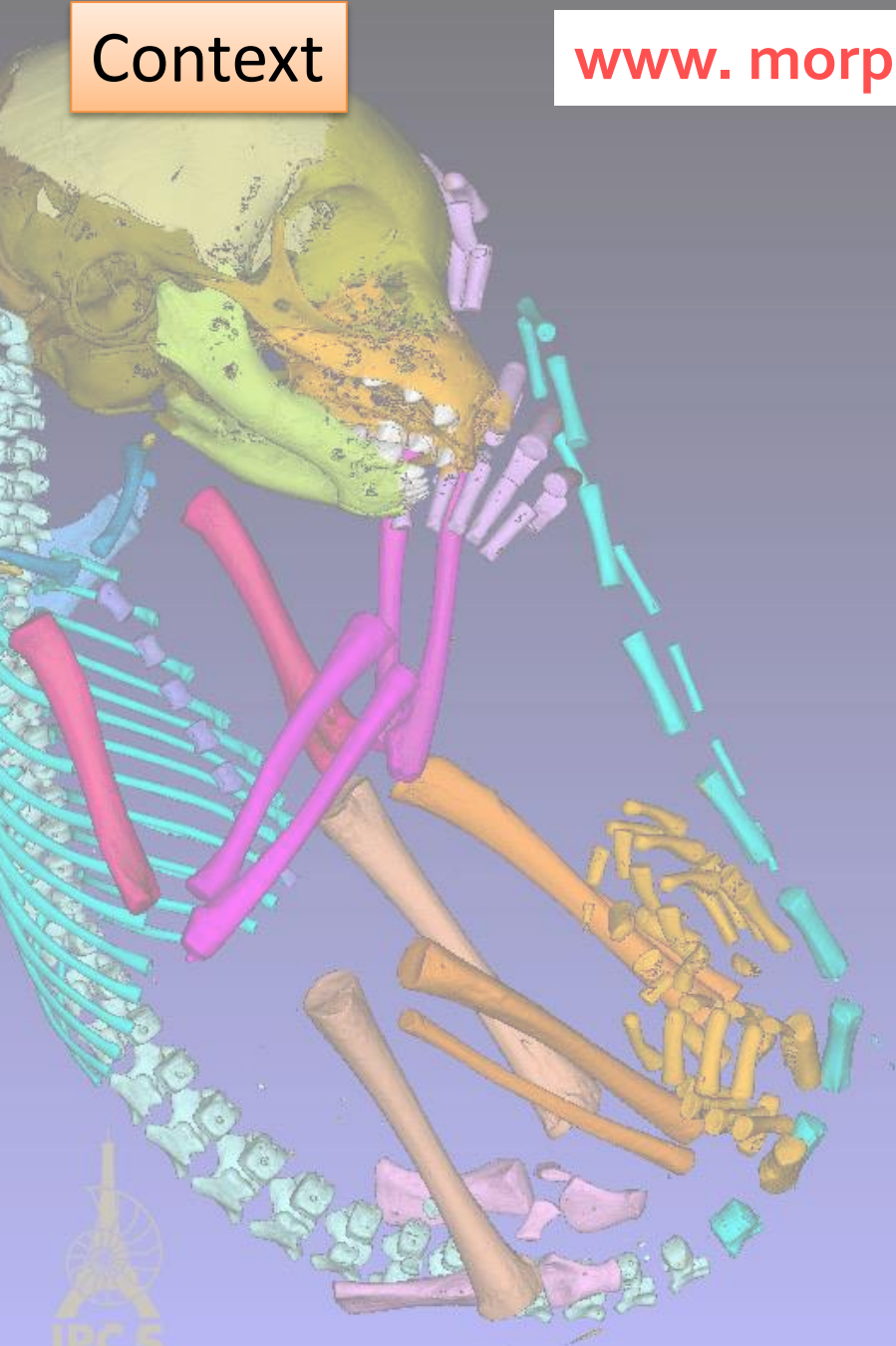


## Context

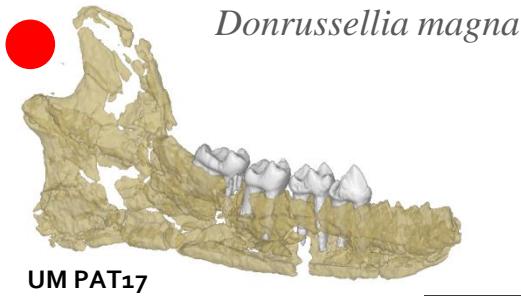
- Since the mid 1990's, **3D data acquisition** and computer-assisted techniques have grown increasingly popular
- **No standard 3D model software** has emerged : commercial software / in-house solutions / solutions designed by non-biologists
- Need to **exchange 3D data** has increased

Context

[www.morphomuseum.com](http://www.morphomuseum.com)



## A platform to publish 3D models (Database + Journal)



*Donrussellia magna*

UM PAT17

Current Issue

Type specimen



Holotype specimen of *Donrussellia magna*, an adapiform primate from the early Eocene (MP7) of Southern France

Anusha Ramdarshan, Marc Godinot, Samuel Bédécarrats and Rodolphe Tabuce

Keywords: Adapiformes; Early Eocene; Holotype; Primates; Southern France

doi: 10.18563/m3.1.2.e2

Abstract Specimens

M3 article infos

**Holotype specimen of *Donrussellia magna*, an adapiform primate from the early Eocene (MP7) of Southern France**

**RAMDARSHAN A., GODINOT M., BÉDECARRATS S. & TABUCE R.\***

\* Institut des Sciences de l'Évolution et Morphologie, Université Montpellier, CNRS, IRD, CC 064, place Eugène Bataillon, 34095 Montpellier Cedex 5, France  
 \* Université de Poitiers, UFR SPA, IFRPp UMR CNRS 7262, Rue 813 - TSA 11096, 6 rue Michel Bequet, 86071, Poitiers Cedex 9, France  
 \* EPHE, Sorbonne Université - CRP - ADSI, CNRS, EPHE-Paris, Muséum national d'Histoire naturelle, 8 rue Duffin, CP88, 75231 Paris Cedex 03, France  
 \* Université de Bordeaux, CNRS, MFC, UMR 5189 BiCSA, Allée Guesbry 33 6300, France Cedex, France

\* corresponding author: rodolphe.tabuce@univ-montp.fr

Abstract: This project presents a 3D dataset and an associated 3D surface model of the holotype of *Donrussellia magna* (UM PAT 17, Primates, Adapiformes) (UM PAT 17 is the only known specimen for the species and consists of a well-preserved left lower jaw with p4-m3). In discussion one of the oldest European primates, eventually dated into the Palaeocene-Eocene Thermal Maximum. Key words: Adapiformes, Eocene, Early Eocene, Primate, Southern France

Submitted 05.06.2015, accepted 18.06.2015, doi: 10.18563/m3.1.2.e2  
 © Copyright Anusha Ramdarshan June 2015

TYPE SPECIMEN

MNH JOURNAL VOL.1 (2)

**DISCUSSION**

Cenozoic represents a European radiation of adapiform primates, possibly also present in Asia. They are clearly related to the North American adapiforms. Similarly not very diverse during the early Eocene, a rapid diversification yielded a wide ecological spectrum of cercaracian primates during the middle Eocene, with body masses ranging from 60g (Archomyces quercy; Ramdarshan, 2011; Ramdarshan, et al., 2012 a and b) to 4000g (Pliopithecus brachytrichus; Fleagle, 2013) and most likely based on insects, fruit, leaves and gums (Ramdarshan, 2011; Ramdarshan et al., 2011 a). However, this group almost disappears at the same time as adapids (i.e., Microscelus, Adapta, Leptaclops) appear in the Eocene fossil record, coinciding with the first anthropoids, which were long (e.g., Godinot, 1958; Manger et al., 2013). Among the first members of the adapiform radiation, *Donrussellia* is the most primitive cercaracian primate (Godinot, 1978, 1996; Rowe et al., 1994), and is recognized as the first econd during the middle Eocene in several European localities considered close to MP7 with D. (distance from Séverac-le-Château (Giraud, 2000), D. provectivella from Riems, Prévost, Southern France (Godinot, 1981), and D. magna from Paléte. The youngest currently known species, *Donrussellia paléte*, is from Aveyron (reference level MP 8+9) (Ravel et al., 1967).

The genus *Donrussellia* was first described by Szalay (1976), based on material originally referred to the so-called *Talchirensis* as ‘*Talchirensis*’ position by Ravel et al. (1967). However, differences with other *Talchirensis* species led Szalay (1976) to describe a new genus. Some material and the description of the new species D. provectivella confirmed the validity of this genus and showed it to be an adapiform (Godinot, 1978). The discovery of UM PAT 17, a nearly complete lower jaw, increased the number of species of the genus, its range, and completed its anatomical knowledge.

*Donrussellia magna* remains however only documented by the holotype, and the morphology of its upper dentition is unknown to date. Godinot (1995 and 1996) proposed that D. magna and *Cretius* share a suite of derived characters suggesting that these two taxa are probably closely related. This hypothesis remains sensitive in the absence of more material, but the subgroup D. (*paléte*) *magna* was erected to reflect the relationship Godinot (1997). In fact, Godinot (1995) suggested that of the upper molars further supported D. magna from D. provectivella from a morphological standpoint, a new separate genus, *Paléte*, should be erected for this tooth. This would furthermore raise the question of the disposal of three instead of two adapiform genera at the Eocene. However, more evidence is needed to support such a view, a convergence with *Cretius* in some dental characters of a large species of *Donrussellia* is possible.

**ACKNOWLEDGMENTS**

We are grateful to S. Jégou and B. Maudoulet for giving access to the specimen. 3D Data generated in this work were produced through the technical facilities of the IMB platform and of the labo CASER. We thank R. Lohren for help with microtomography. We are grateful to M. Olsén and L.

TECHNICAL AND SPECIMEN-RELATED PARAMETERS

Specimen inventory number	UM PAT 17
Species	<i>Donrussellia magna</i>

M3#17\_UM PAT 17

3D surface file model of UM PAT 17 (type specimen of *Donrussellia magna*), which is a well preserved left lower jaw with p4-m3. The teeth (and roots) were manually segmented.

Date citation: Ramdarshan A., Godinot M., Bédécarrats S., Tabuce R., 2015, MNH J. UM PAT 17. doi: 10.18563/m3.1.2.e2

Specimen infos

- Collection:** Université Montpellier Institut des Sciences de l'Évolution
- Inventory number:** UM PAT 17
- Sex:** indet
- Age group:** Adult
- Age (if applicable):** Early Eocene
- Material Type:** Mandible
- Origin:** Southern France, Paléte

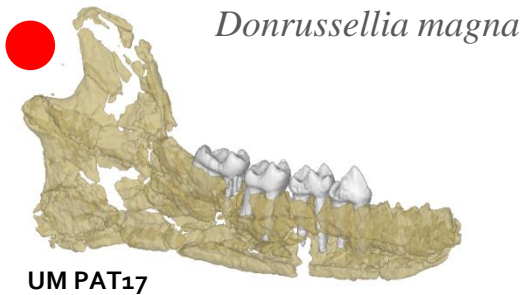
- Taxonomy**
- Class:** Mammalia
- Order:** Primates
- Family:** Notharctidae
- Genus:** *Donrussellia*
- Species:** *magna*

Description

UM PAT 17 is the holotype specimen of *Donrussellia magna*. It is a well preserved left lower jaw with p4-m3



## A platform to publish 3D models (Database + Journal)



Current Issue

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Cenozoicium represents a European radiation of adapiform primates, possibly also present in Asia. They are closely related to the North American adapiforms. Similarly not very diverse during the early Eocene, a rapid diversification yielded a wide ecological spectrum of cenozoicium during the middle Eocene, with body masses ranging from 60g (*Achoenonyx* spenceri; Ramdarshan, 2011; Ramdarshan, et al., 2012 a and b) to 4000g (*Protopithecus* *brachytrichus*; Fliegler, 2013) and most likely based on insects, fruit, leaves and grass (Ramdarshan, 2011; Ramdarshan et al., 2011 a). However, this group started diversify at the same time as adapids (i.e., *Micropithecus*, *Adaptis*, *Leptacropis*) appear in the European fossil record, coexisting with the first hominoids, which were more (e.g., Godinot, 1958; Margot et al., 2013). Among the first members of the adapiform radiation, *Donrussellia* is the most primitive cenozoicium genus (Godinot, 1978, 1995; Rowe et al., 1994), and is registered in the fossil record during the earliest Eocene in several European localities considered close to MP7 with *D.* *lanceolatus* from Sévérac-le-Château (Gibaud, 2000), *D.* *provisialis* from Rians, Provence, Southern France (Godinot, 1981), and *D.* *magna* from Paléto. The youngest currently known species, *Donrussellia paléto*, is from Aveyron (reference level MP 8+9) (Ravel et al., 1987). The genus *Donrussellia* was first described by Stolley (1976), based on material originally referred to the accepted *Taillirodon* as ‘*Taillirodon*’ by Ravel et al. (1987). However, differences with other *Taillirodon* species led Stolley (1976) to describe a new genus. Better material and the description of the new species *D.* *provisialis* confirmed the validity of this genus and showed it to be an adapiform (Godinot, 1978). The discovery of UM PAT 17, a nearly complete lower jaw, increased the number of species of the genus, its range, and completed its anatomical knowledge. *Donrussellia magna* remains however only documented by the holotype, and the morphology of its upper dentition is unknown to date. Godinot (1995 and 1999) proposed that *D.* *magna* and *Cenozoicium* share a suite of characters suggesting that these two taxa are probably closely related. This hypothesis remains sensitive in the absence of more material but the subgenus *D.* (*phalio*) *magna* was erected to reflect the relationship (Godinot, 1997). In fact, Godinot (1995) suggested that of the upper incisors further appeared *D.* *magna* from *D.* *provisialis* from a morphological standpoint, a new separate genus, *Paléto*, should be erected for this form. This would furthermore raise the question of the disposal of three instead of two adapiform genera in the Eocene. However, more evidence is needed to support such a view, a comparison with *Cenozoicium* in more dental characters of a large species of *Donrussellia* is possible.

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**Specimen infos**

**Collection**  
 Collection: Université Montpellier, Institut des Sciences de l'Évolution

**Inventory number:** UM PAT 17

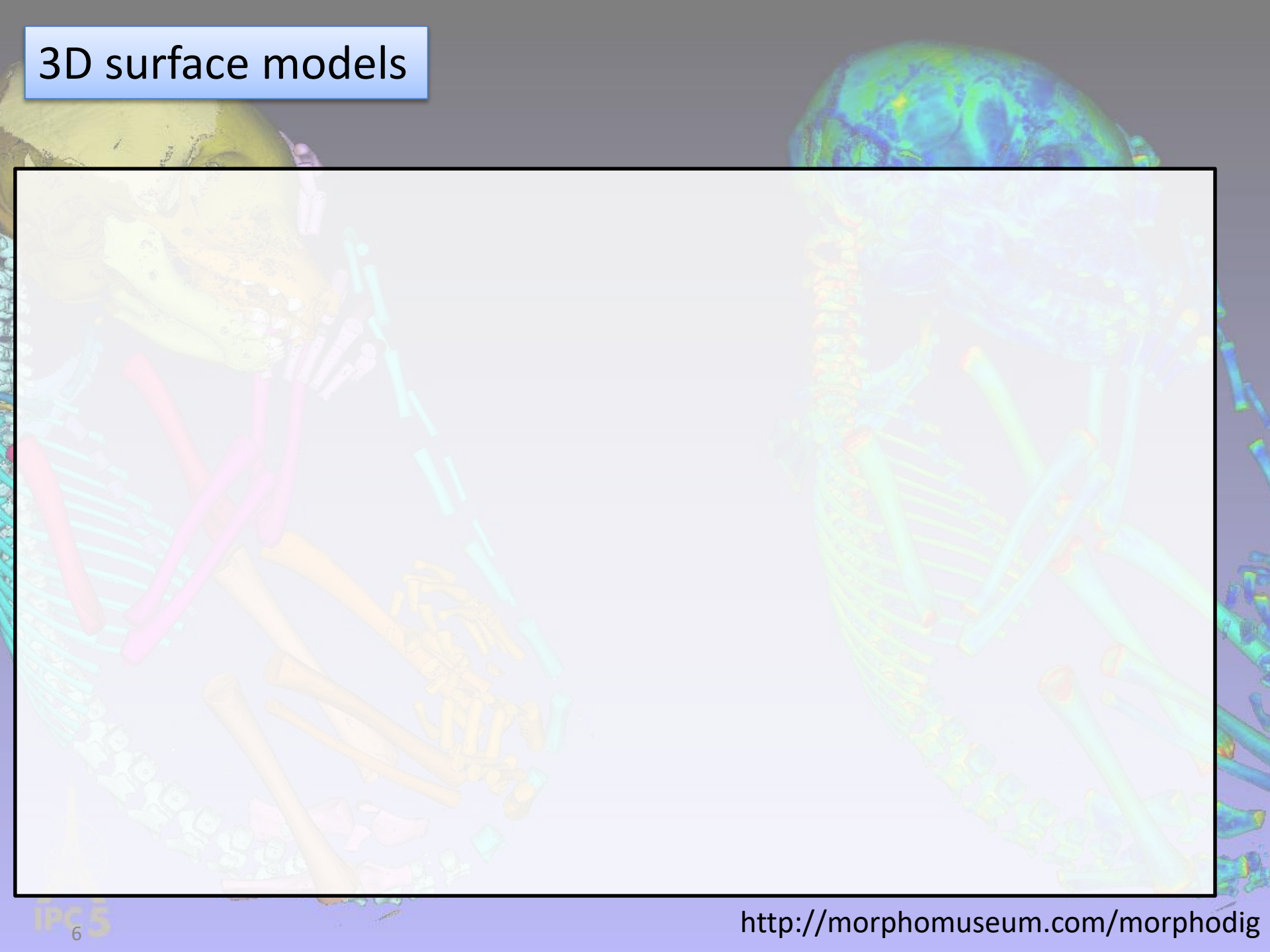
**Information**  
 Sex: indet  
 Age group: Adult  
 Age (if applicable): Early Eocene  
 Mandible Type: Mandible

**Taxonomy**  
 Class: Mammalia  
 Order: Primates  
 Family: Notharctidae  
 Genus: *Donrussellia*  
 Species: *magna*

**Description**  
 UM PAT 17 is the holotype specimen of *Donrussellia magna*. It is a well preserved left lower jaw with p4-m3

Software are needed to create 3D biological models!

# 3D surface models



# 3D surface models

CT-Data

MRI-Data

Laser-Scanner Data  
Photogrammetry etc...

Segmentation

Surface Files

# 3D surface models

CT-Data

MRI-Data

Laser-Scanner Data  
Photogrammetry etc...

Segmentation

Surface Files

**Analyses** => Geometric  
morphometrics, anatomy atlases,  
fossil reconstructions

**Visualization**  
**3D printing**



# 3D surface models

CT-Data

MRI-Data

Laser-Scanner Data  
Photogrammetry etc...

Segmentation

Surface Files

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morphometrics, anatomy atlases,  
fossil reconstructions

**Visualization**

**3D printing**

## 3D surface models

3D points (x,y,z)  
+ connectivity  
« wireframe »



*Erythrocebus patas* femoral head

- Free editors such as **MeshLab**, **Blender** are not designed by biologists.

# 3D surface models

3D points (x,y,z)  
+ connectivity  
« wireframe »



*Erythrocebus patas* femoral head

- Free editors such as **MeshLab**, **Blender** usually handle MUCH better surfaces 1 by 1

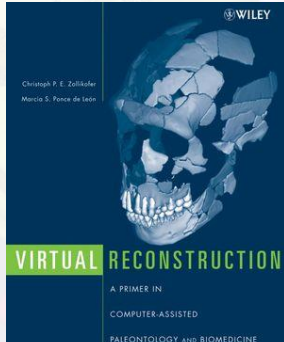
**MorphoDig**

= 3D surface model editor



**MorphoDig**

= 3D surface model editor

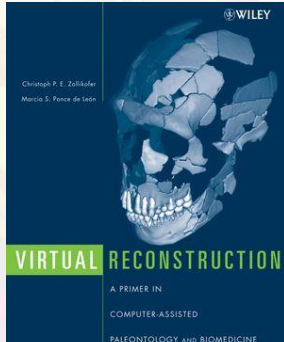


## Design concepts

Zollikofer and Ponce  
de León  
(AIM, Zürich)

**MorphoDig**

= 3D surface model editor



Design concepts

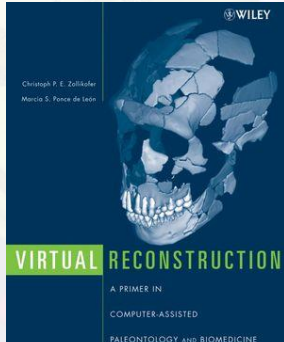
Zollikofer and Ponce  
de León  
(AIM, Zürich)



User interface

**MorphoDig**

= 3D surface model editor



Design concepts

Zollikofer and Ponce  
de León  
(AIM, Zürich)



Data structure

Analysis filters

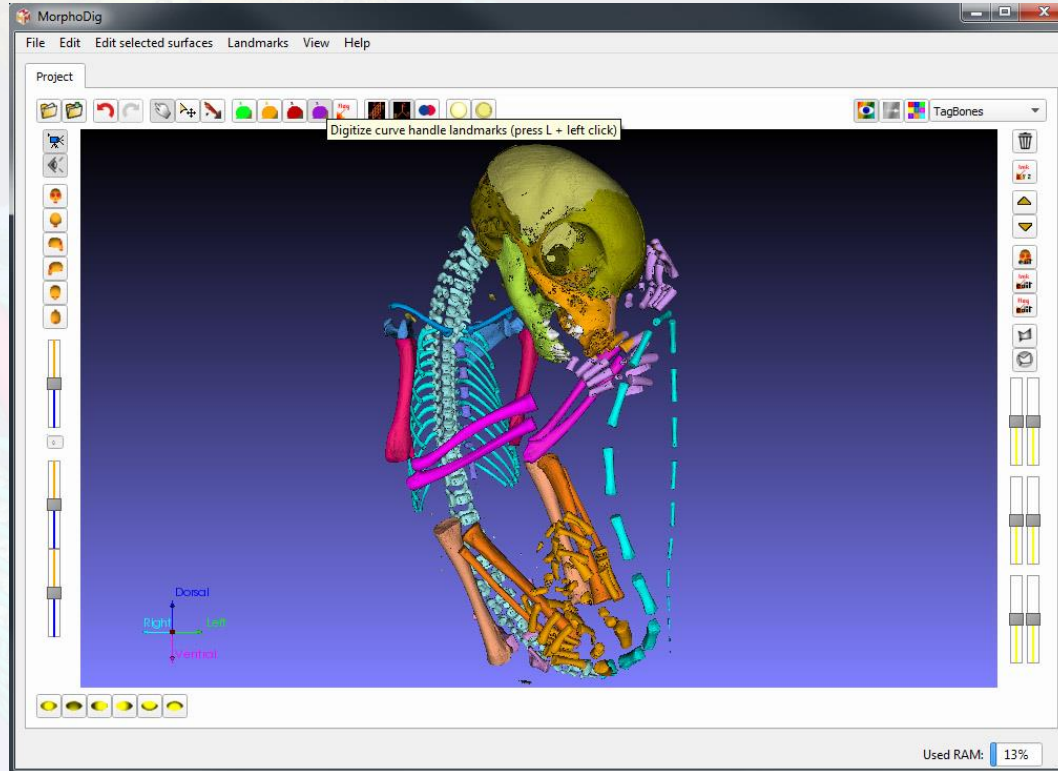
Fast 3D rendering



User interface

# MorphoDig

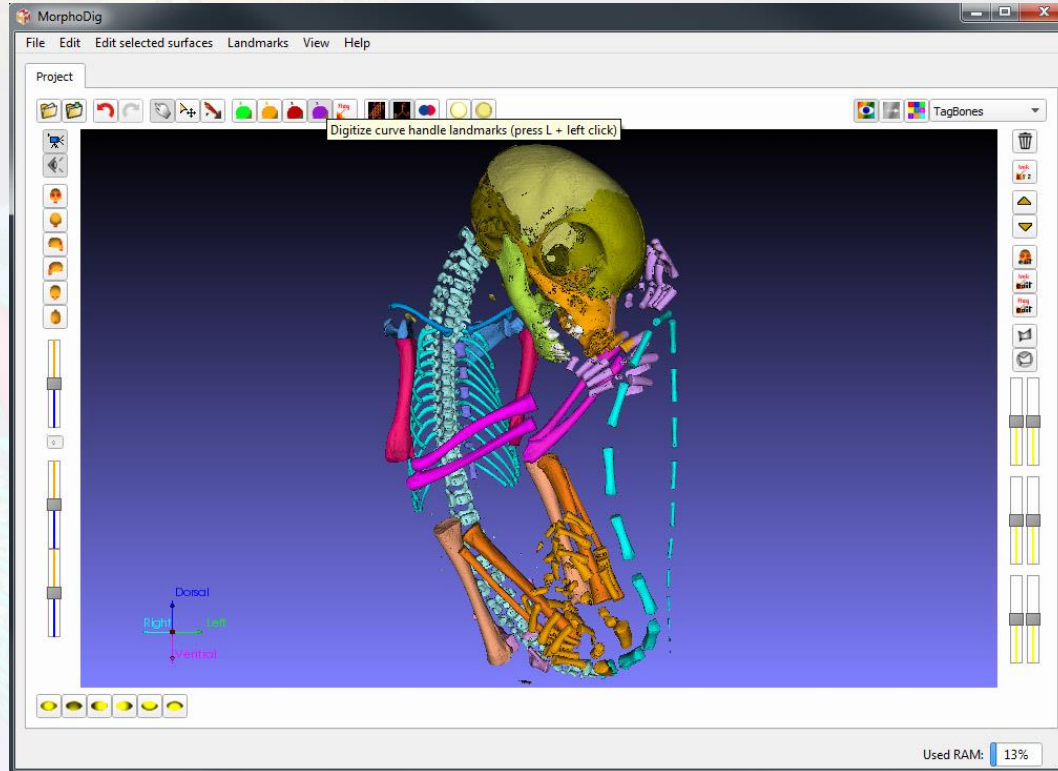
= 3D surface model editor





**MorphoDig**

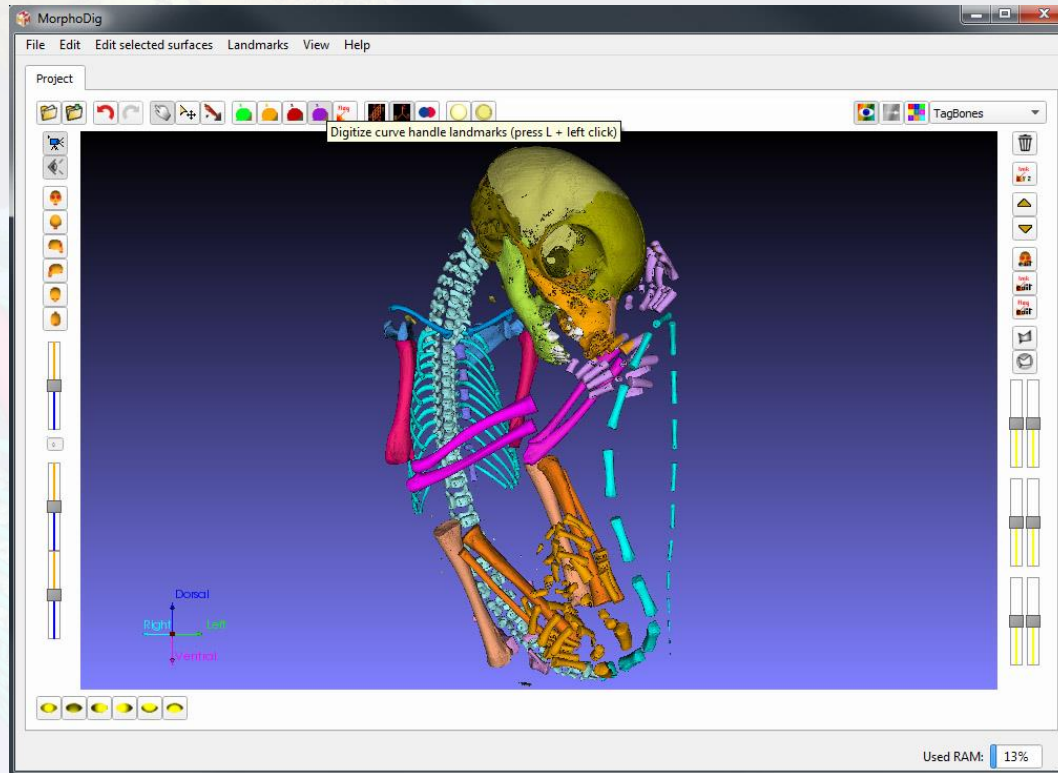
= 3D surface model editor



→ User friendly interface to handle hundreds of 3D surfaces at once

**MorphoDig**

= 3D surface model editor



- User friendly interface to handle hundreds of 3D surfaces at once
- Analyze 3D surfaces in standard file formats (.stl, .ply, .vtk)

**MorphoDig**

= 3D surface model editor

Cross-platform (C++)

**MorphoDig**

= 3D surface model editor

Cross-platform (C++)

Current distribution : Windows

**MorphoDig**

= 3D surface model editor

Cross-platform (C++)

Current distribution : Windows

**Distribution:** help is needed

→ Linux

→ macOS



<https://github.com/morphomuseum/MorphoDig>

# Functionalities



# Functionalities

→ You may find many of MorphoDig's features in other free/commercial software

# Functionalities

- You may find many of MorphoDig's features in other free/commercial software
- MorphoDig's design is thought for biologists



# Functionalities

→ You may find many of MorphoDig's features in other free/commercial software

→ MorphoDig's design is thought for biologists



→ Undo



Redo

- load surfaces/landmarks
- delete surfaces/landmarks
- move surfaces/landmarks
- tag surfaces

## Visualization: translucency

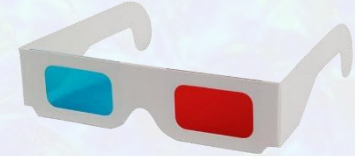
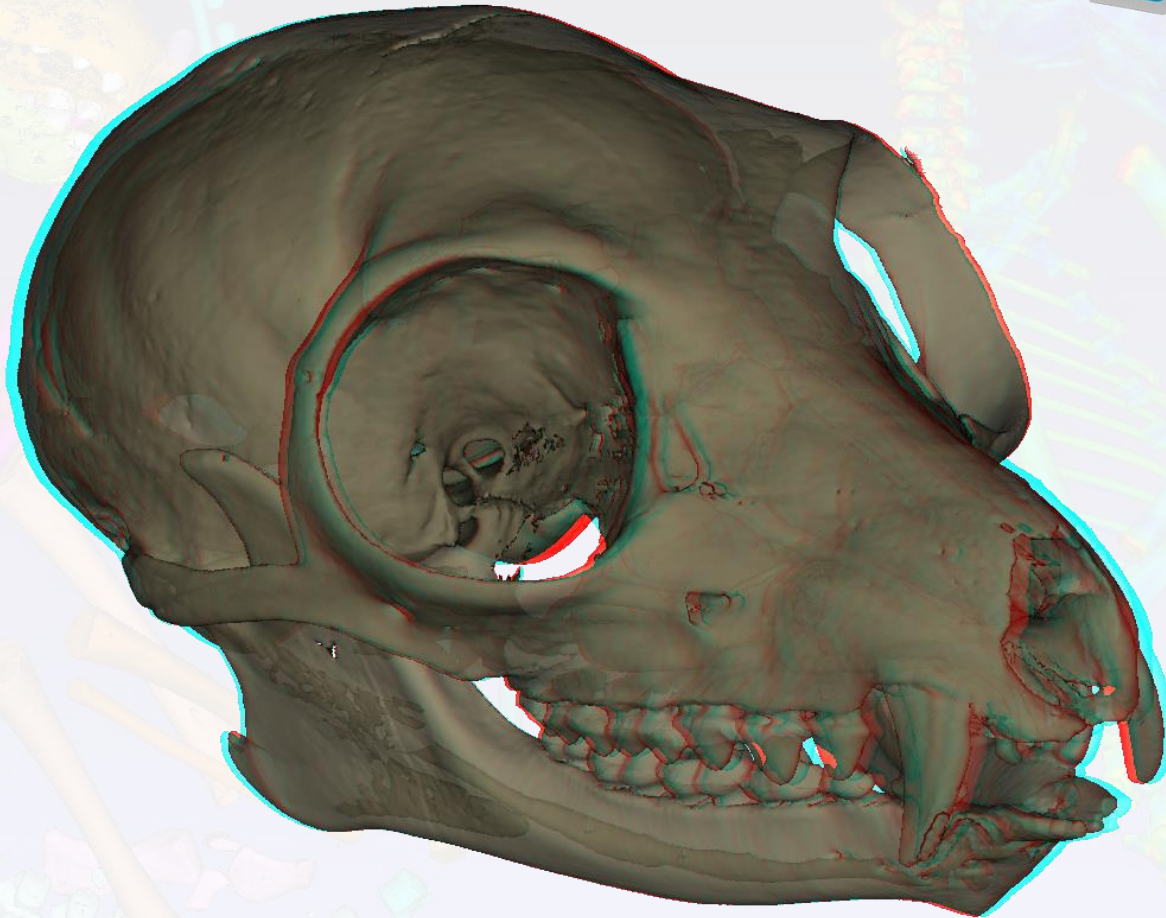
Fast translucency rendering permits also to visualize inner structures



*Pan paniscus*

# Functionalities

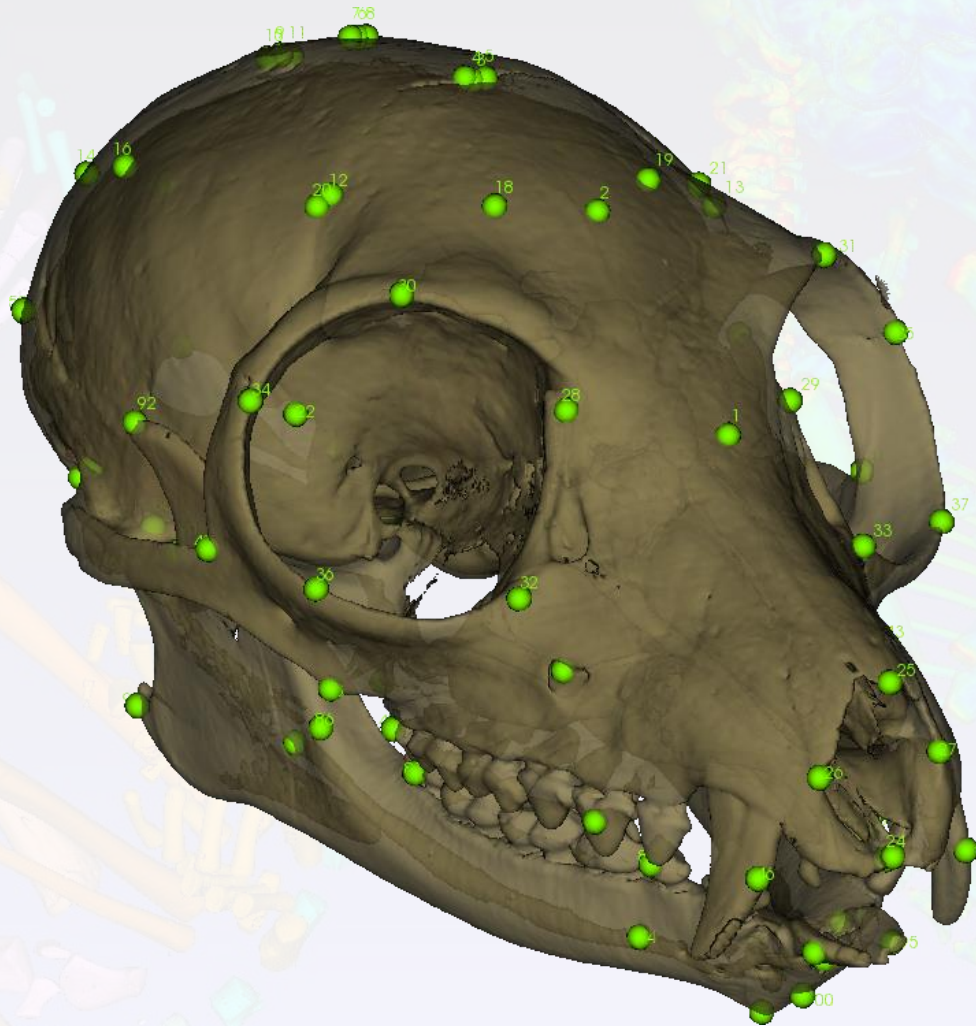
## Visualization: anaglyph rendering



*Eulemur mongoz*

# Functionalities

## Landmark digitization



Undo

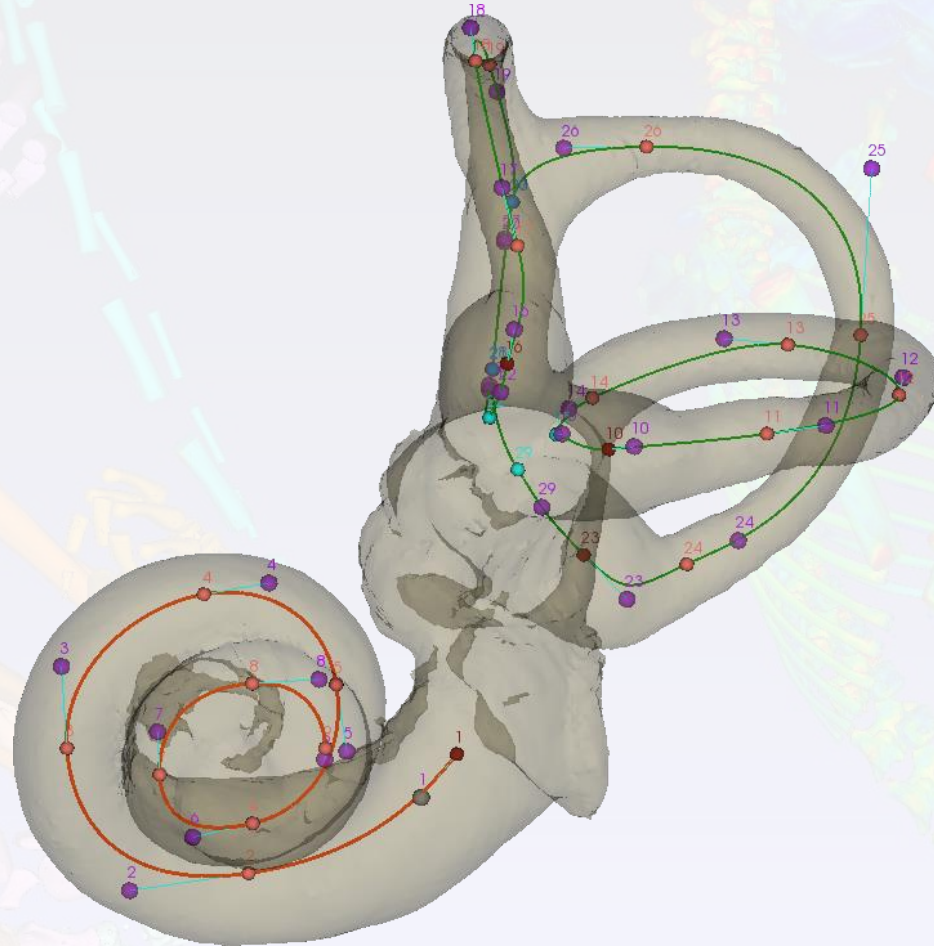


Redo

*Eulemur mongoz*

## Curve semi-landmark digitization

convenient for semi-landmark digitization on inner ears



Undo

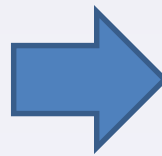


Redo

*Callithrix jacchus*

## Interactions with surface objects

Possibility to select-and-move many surfaces objects at once (not 1 by 1)



Undo

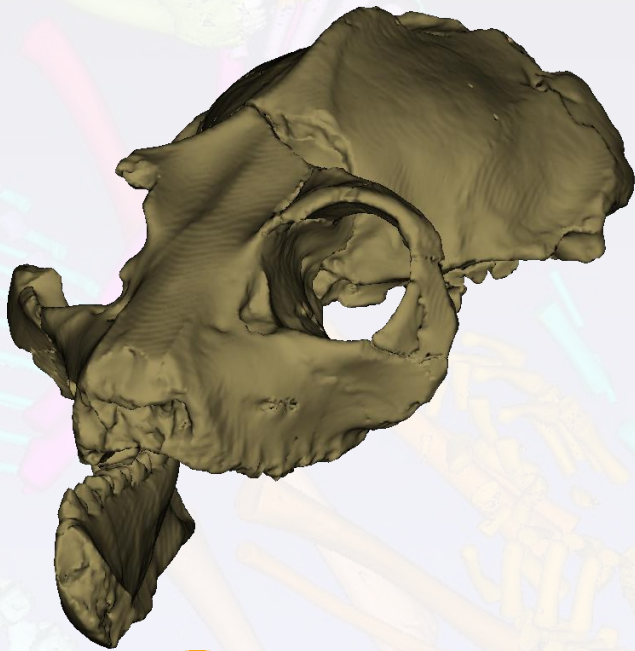


Redo

*Canariomys bravoii*

## Data processing: mirror

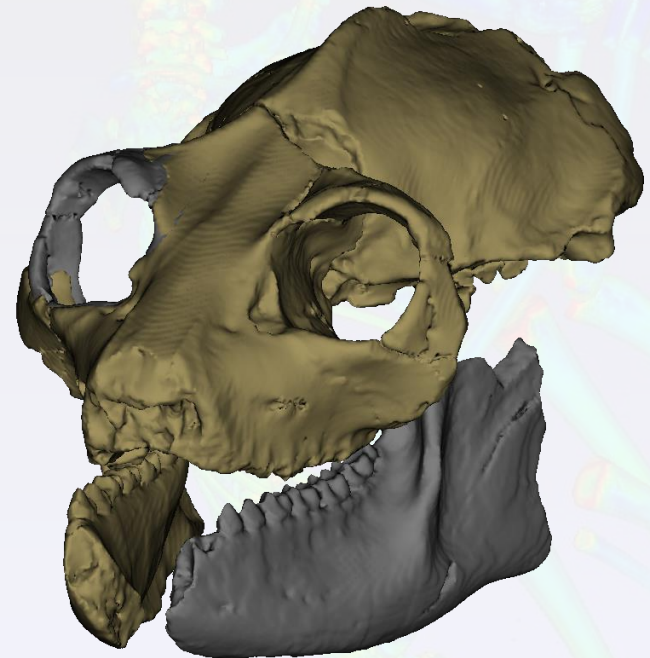
Mirroring of surface objects (virtual restoration)



Undo



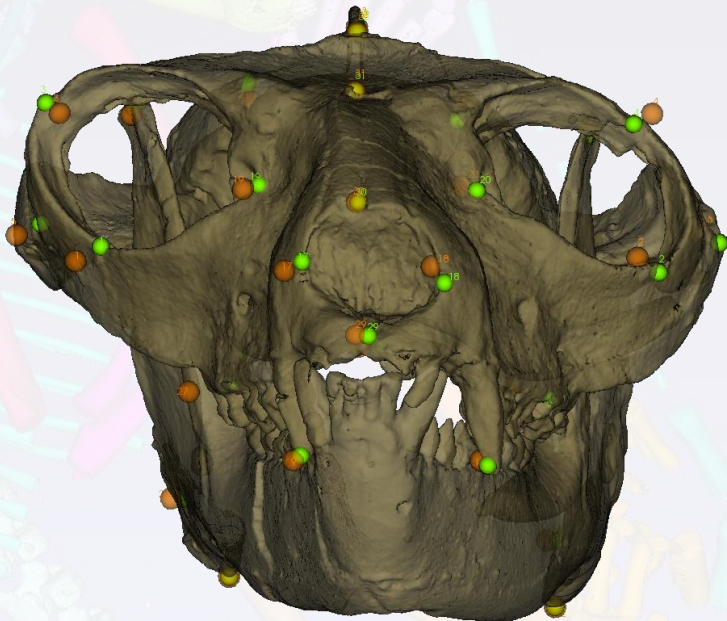
Redo



*Palaeolemur betillei*

## Data processing: retro-deformation

Via TPS (thin plate splines) deformation using 2 Sets of landmarks



Undo



Redo

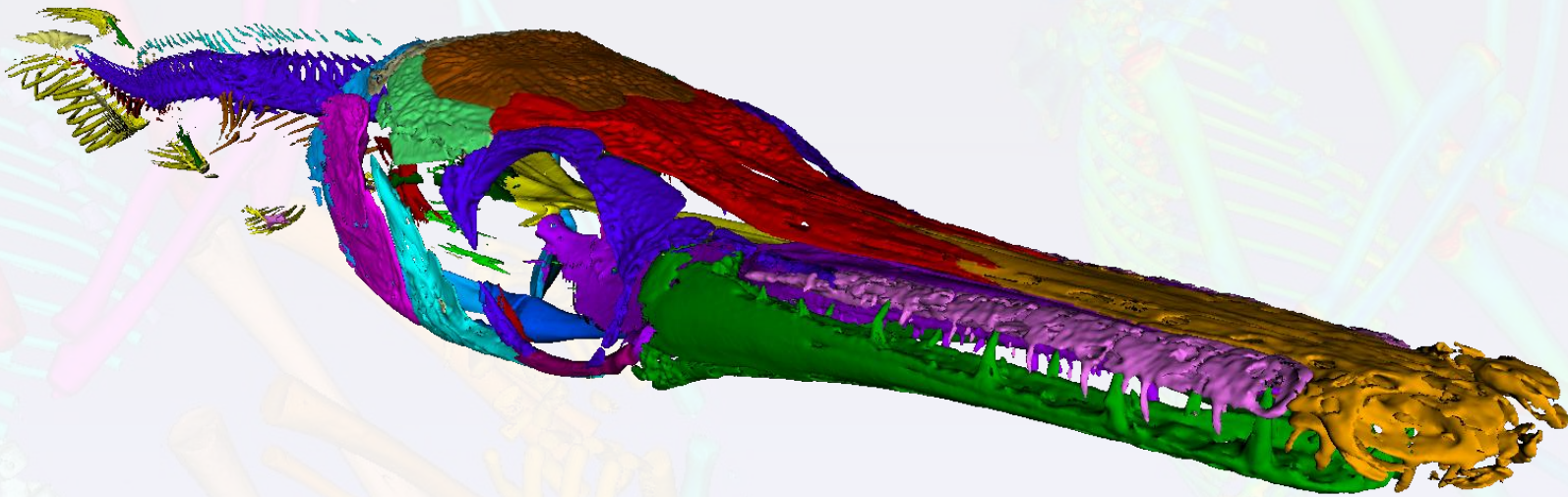
*Notharctus tenebrosus*



# Functionalities

## Data manipulation

Surface tagging (  ,  ,  ) to create anatomy atlases



Undo



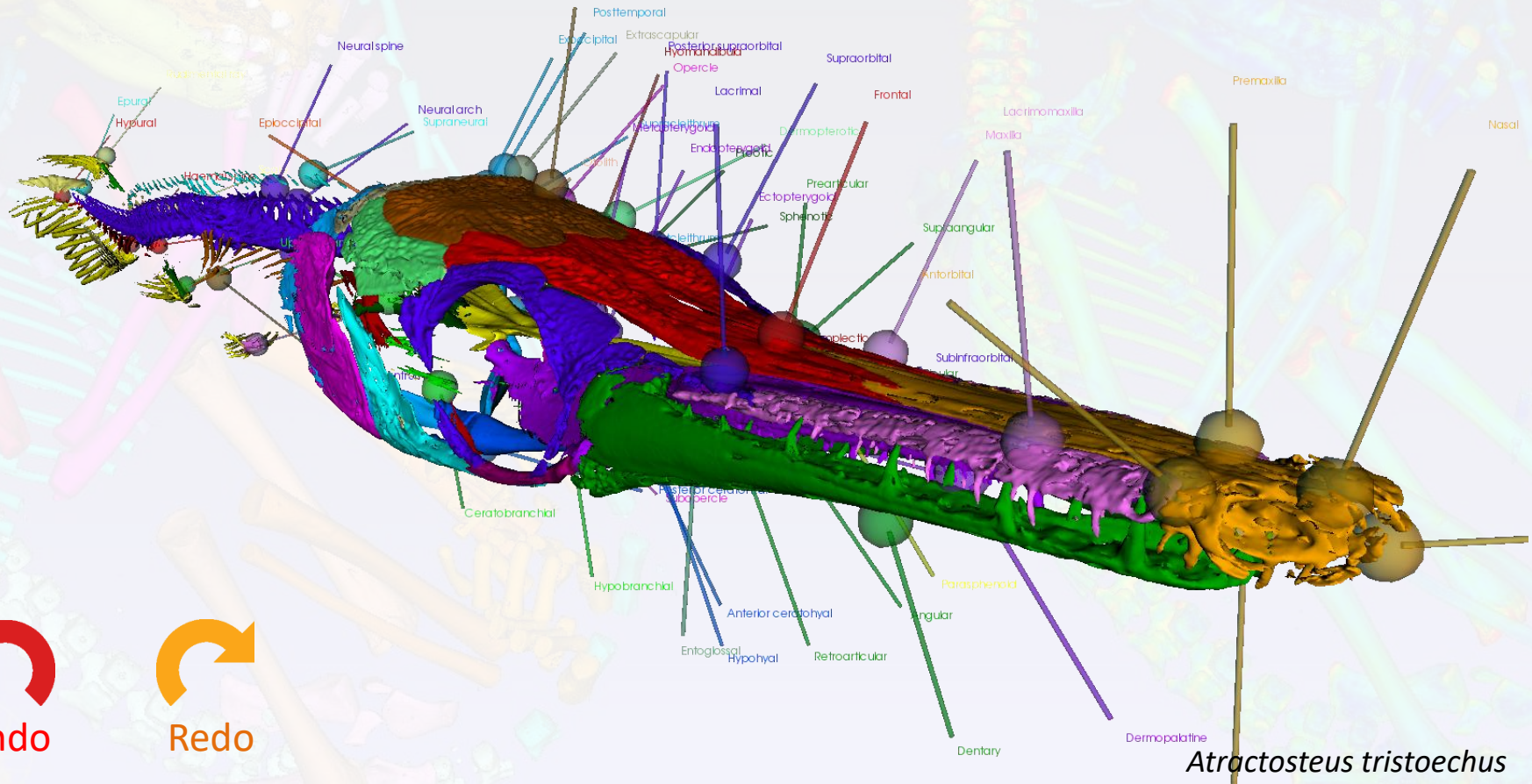
Redo

*Atractosteus tristoechus*

# Functionalities

## Surface labeling

Digitize flags on structures of interest



Undo



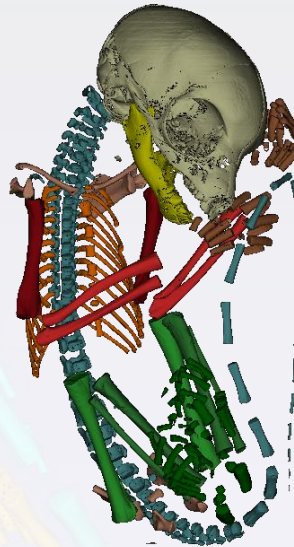
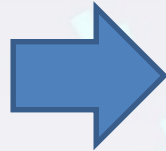
Redo

## Surface decomposition

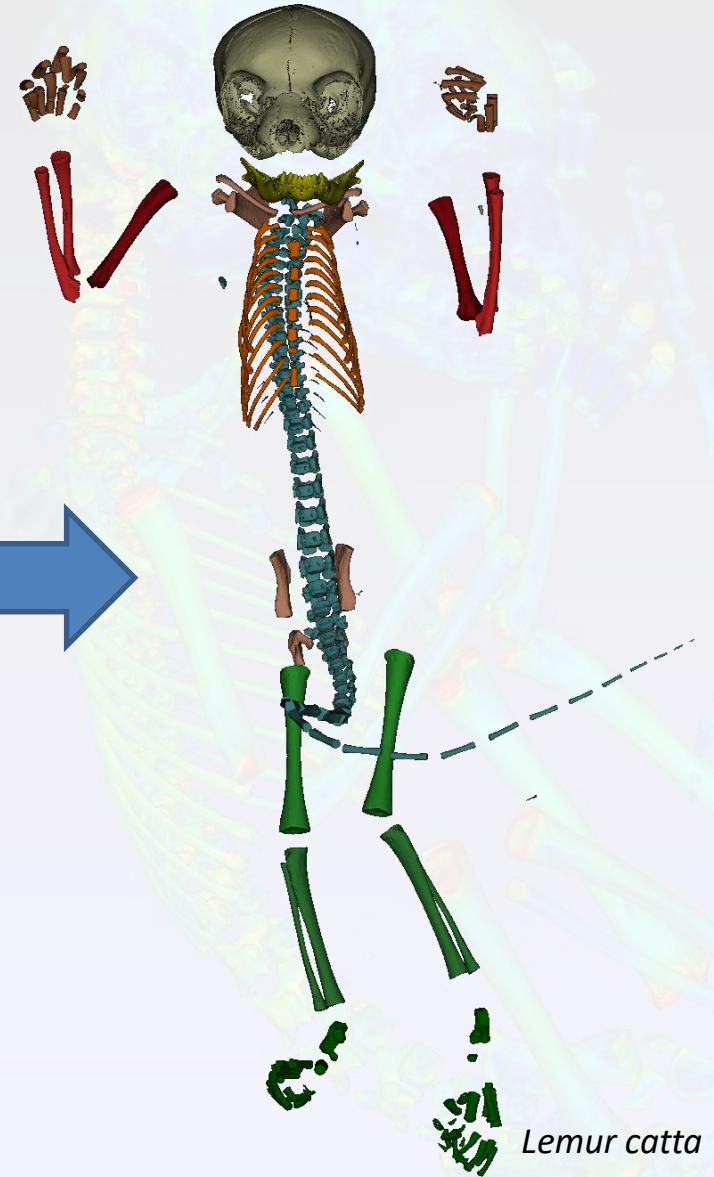
Decompose automatically a surface into a set of non-connected surface objects



1 single surface object



many single surface objects



Undo



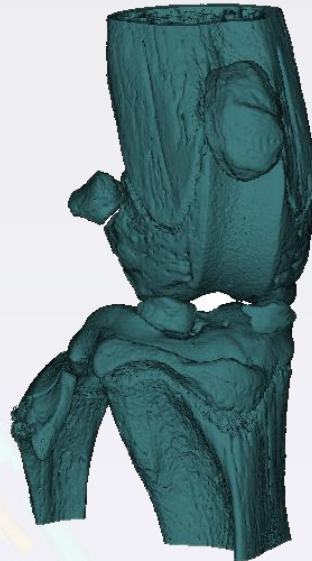
Redo

## Surface combination

Several 3D surfaces can be grouped together inside a single surface



Set of 3d surfaces



1 single surface



**3D  
printing**



Undo

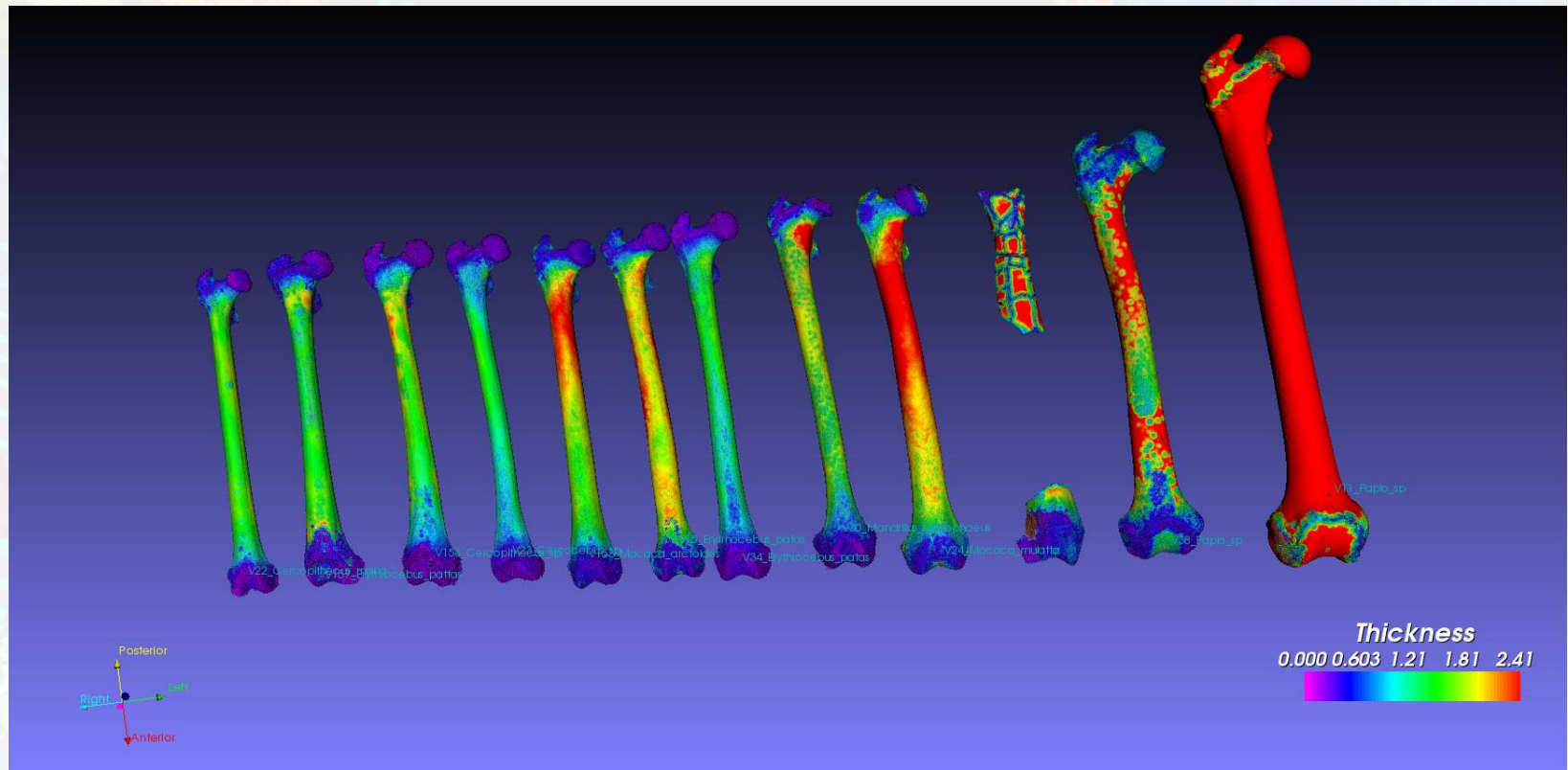


Redo

*Mus musculus' knee*

## Analysis & visualization

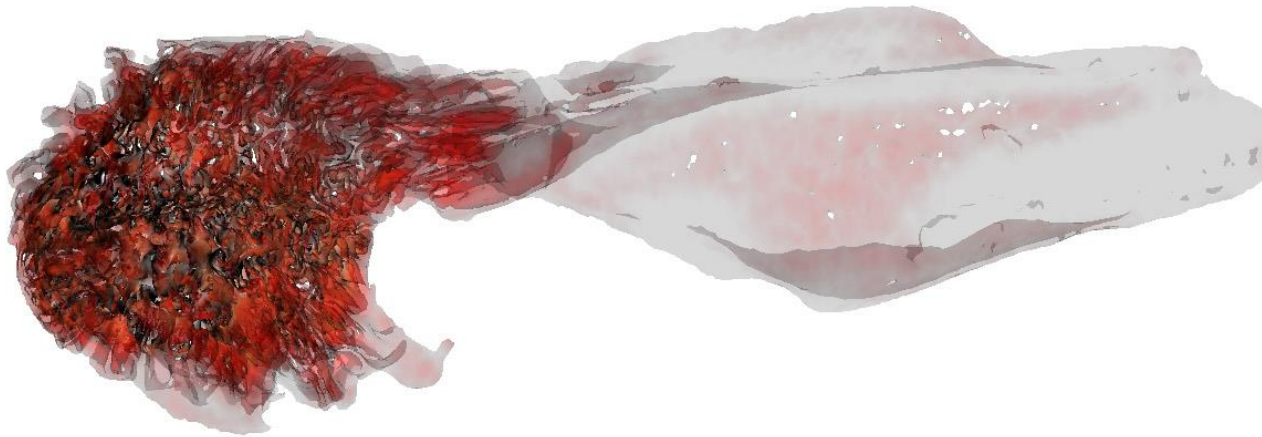
### Bone thickness



Primate femur bone thickness (~20 millions points)

## Analysis & visualization

bone complexity

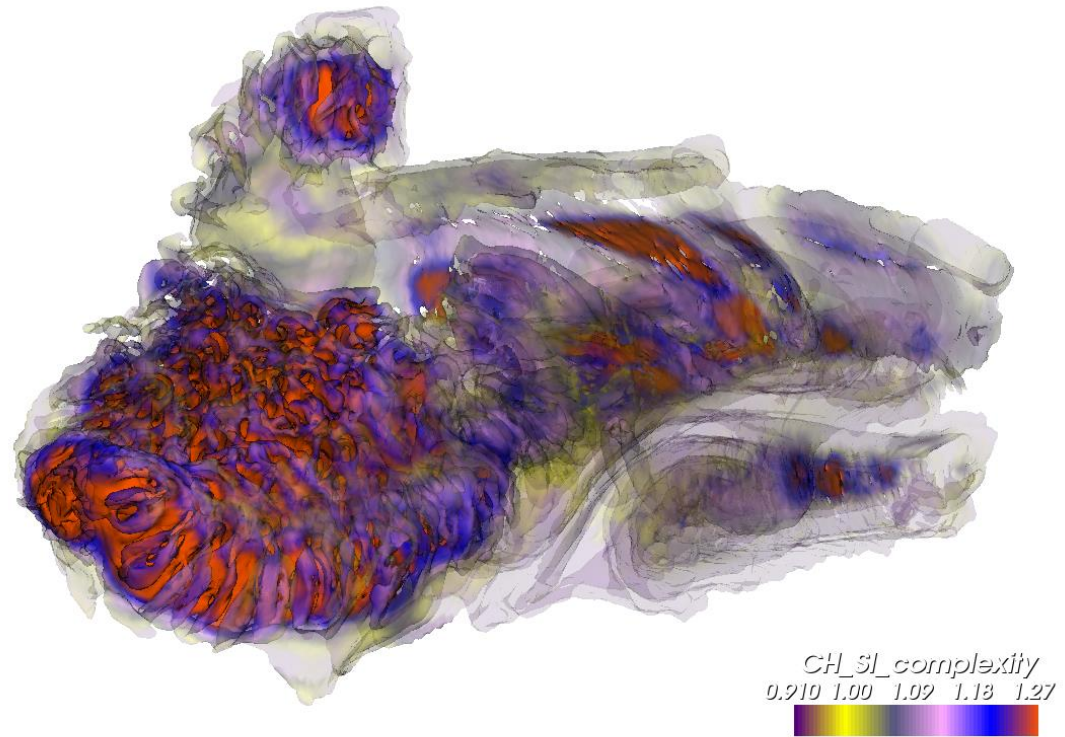
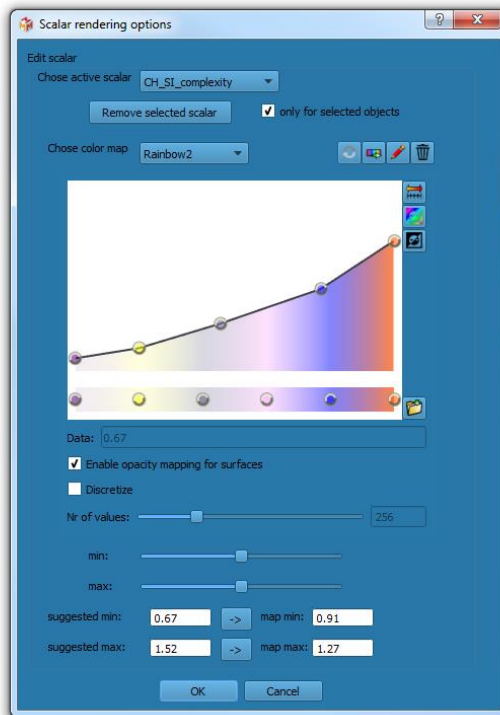


Complexity2mm\_surface\_area  
0.570 0.792 1.01 1.24 1.46

Surface complexity of turbinal bone of *Orycteropus afer*

## Visualization

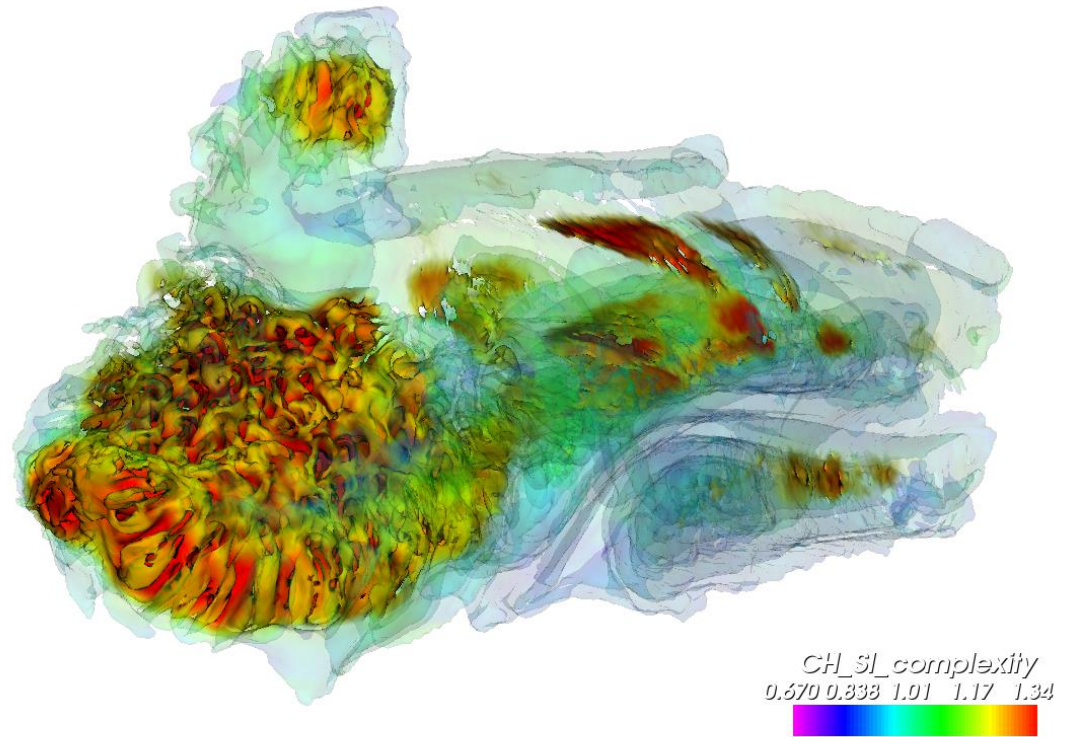
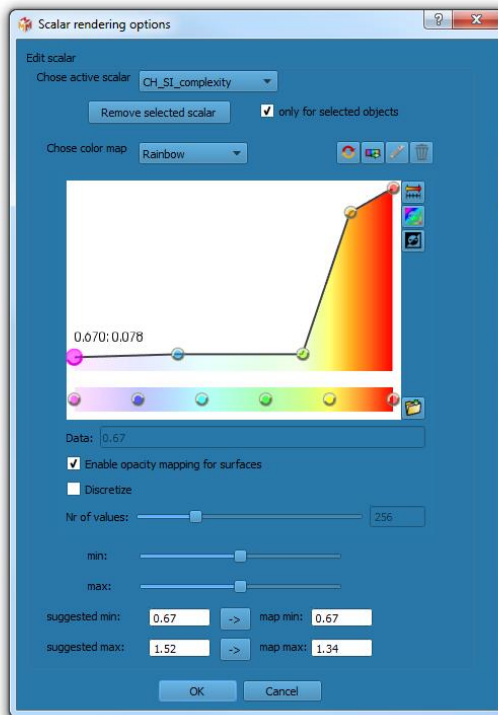
color-opacity maps : interactive edition



Surface complexity of turbinal bones of *Orycteropus afer*

## Visualization

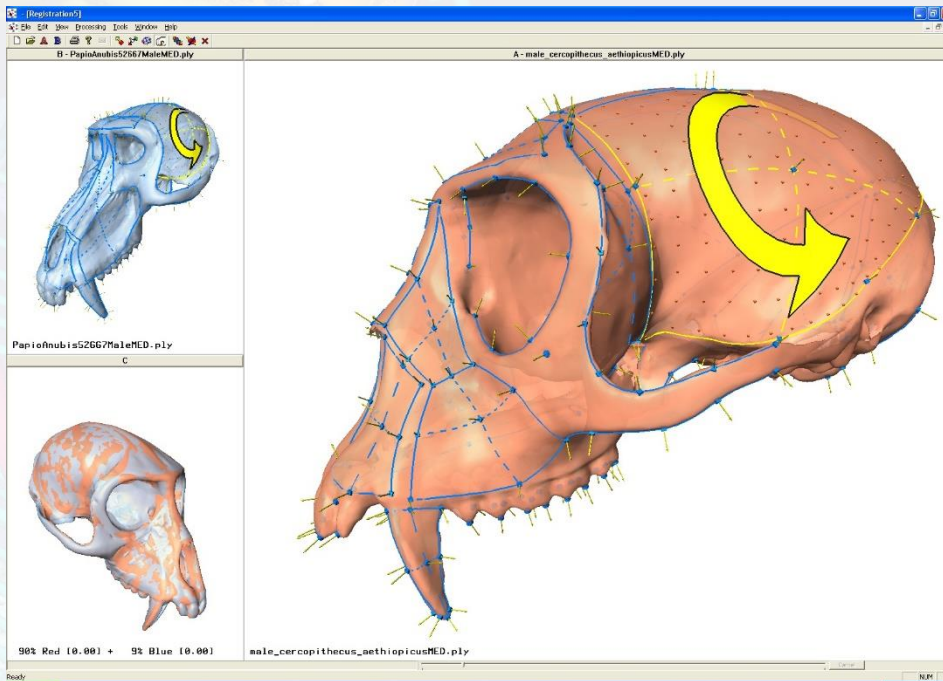
color-opacity maps : interactive edition



Surface complexity of turbinal bones of *Orycteropus afer*



## MorphoDig: future developments reimplementation of “Landmark editor” functions

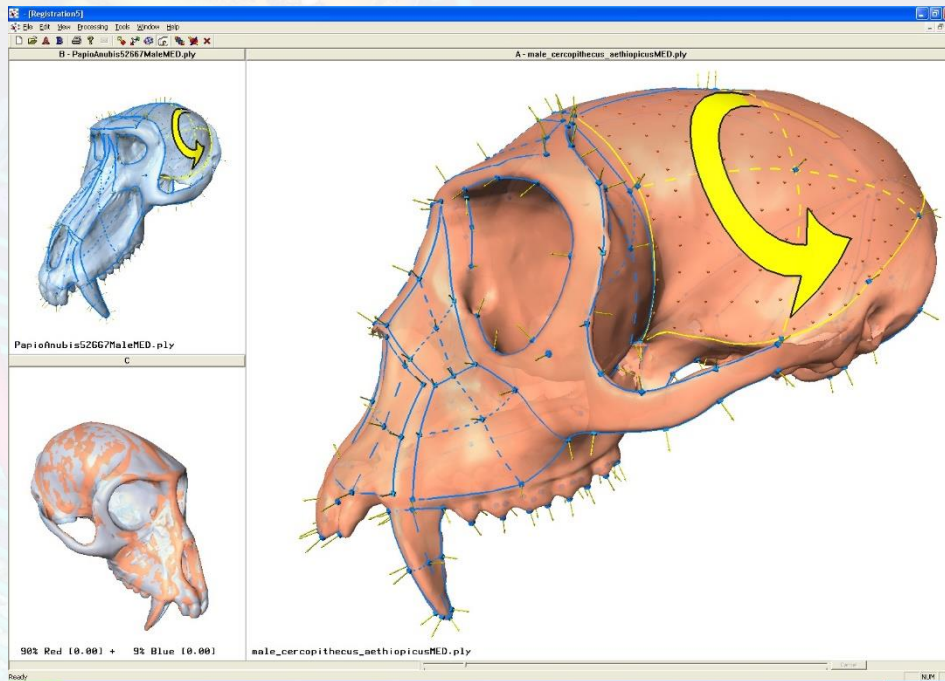


Software not maintained  
since 2007

Not available anymore  
for download

➔ Still used a lot in  
Geometric  
Morphometric studies

## MorphoDig: future developments reimplementation of “Landmark editor” functions



→ semi-landmarks  
digitization on  
« patches »

→ Semi-automatic  
digitization using an  
« atlas »

## MorphoDig: future developments

→ MorphoDig today : input/output = **3D surface files**

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Segmentation editor ?

**Thanks a lot!**  
**IPC5 staff!**



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