Introduction to Computational Anatomy

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Motivation

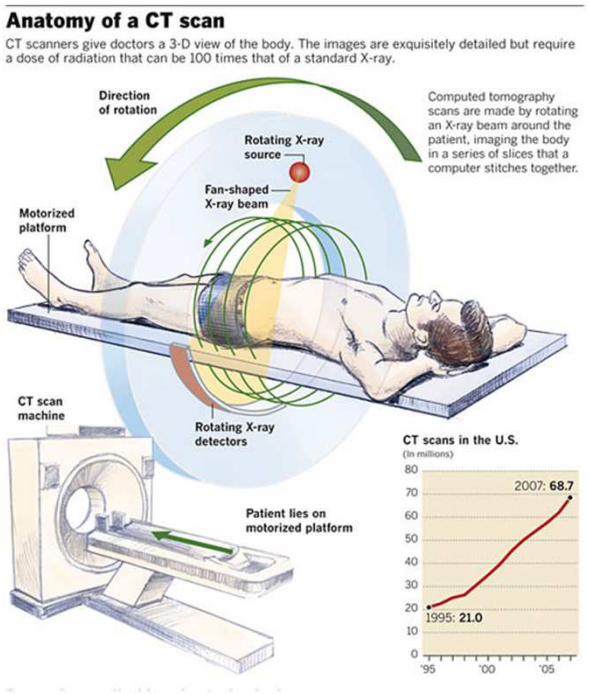
- General overview on computational tools helping the study of Anatomy

- Study of anatomical ***shape*** and ***motion***
  - Standard technique
    - 3D medical images, biomechanics
  - Research advances
    - Segmentation, acquisition, simulation

Part I – Anatomical Shape

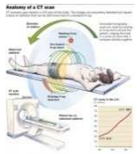
3D medical image

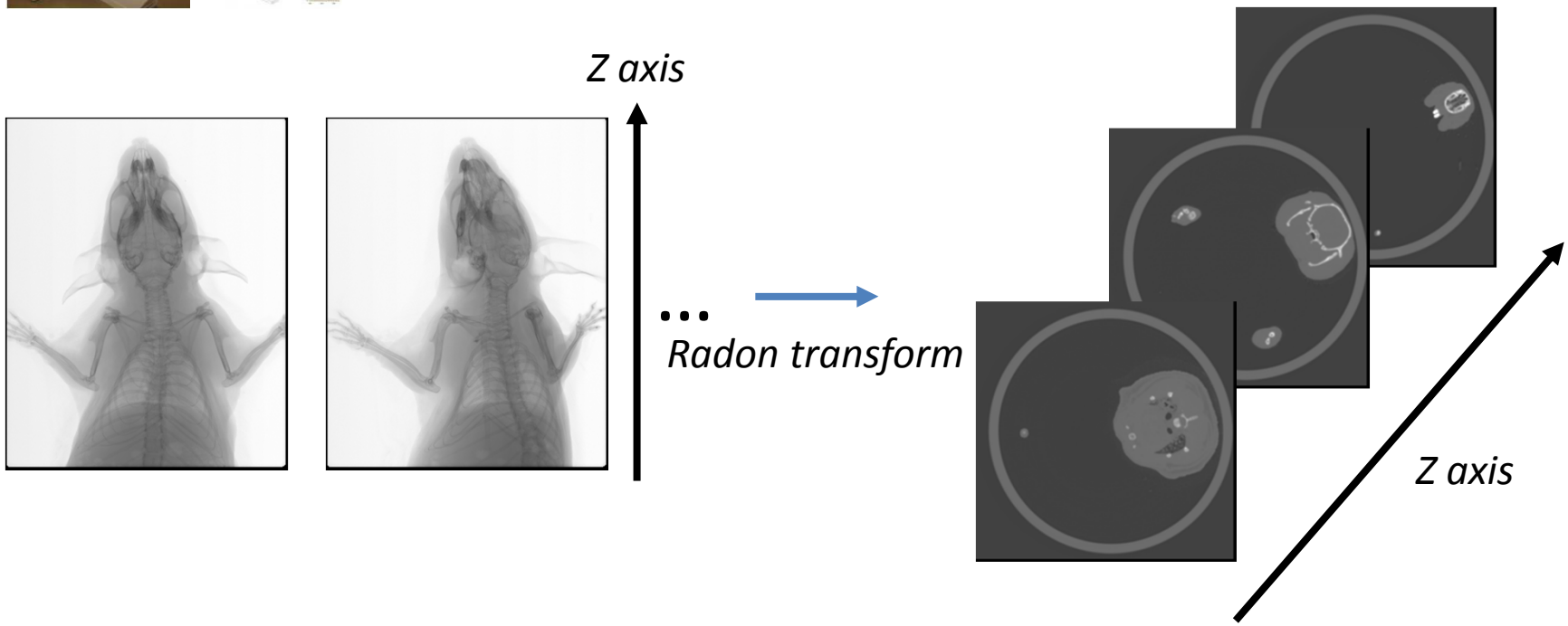
- Xray CT scanner (Computed Tomography)



3D medical image

- Xray CT scanner (Computed Tomography)

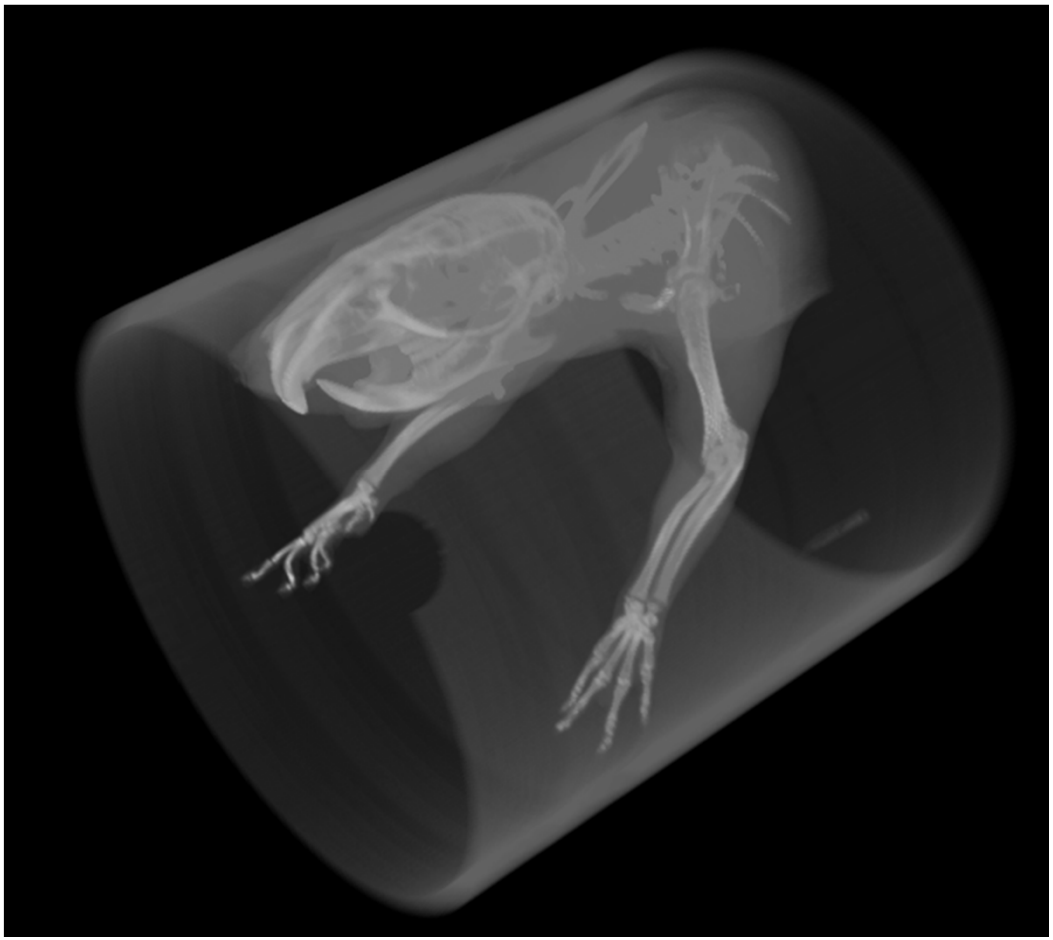




Demo : original and slice images

3D medical image

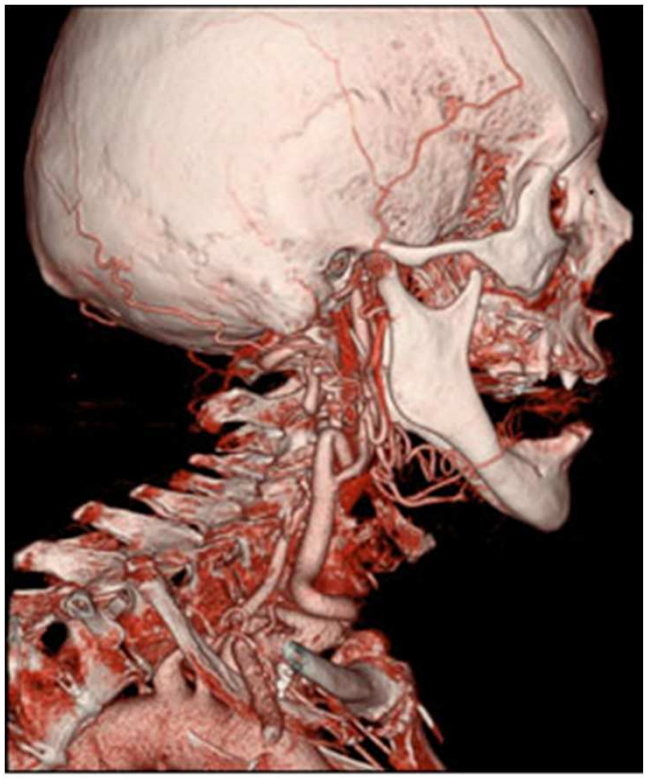
- Xray CT scanner : 3D texture rendering



demo: 3Dview

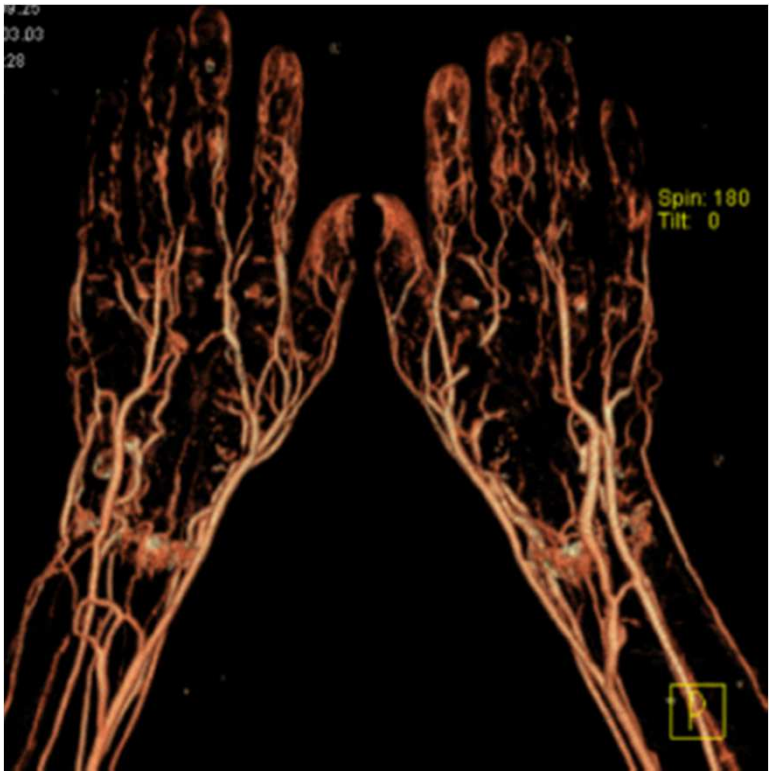
3D Medical image

- Xray CT scanner : enhancing visualization



A CT SCAN OF THE HEAD

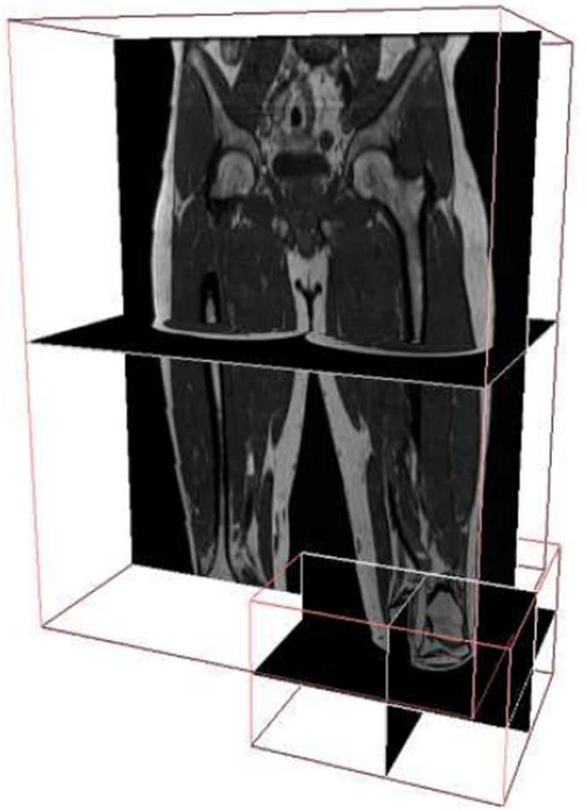
Ray casting rendering



Radiocontrast agent

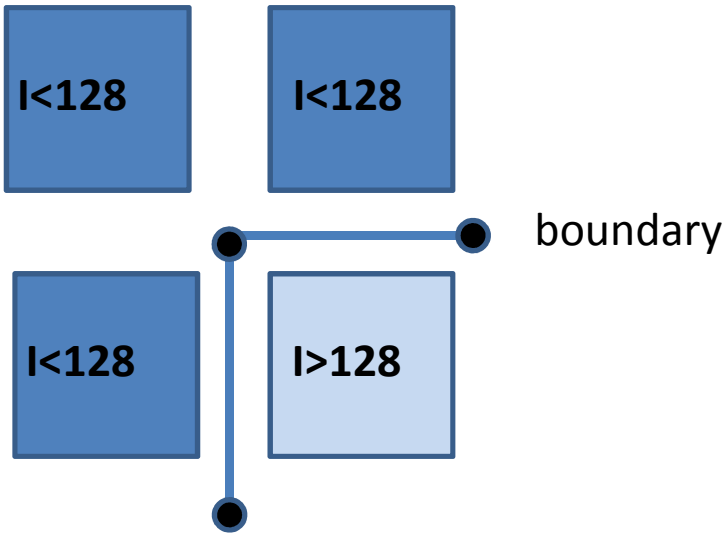
3D Medical image

- MRI (Magnetic Resonnance Image)
  - better vizualisation of muscles tissues

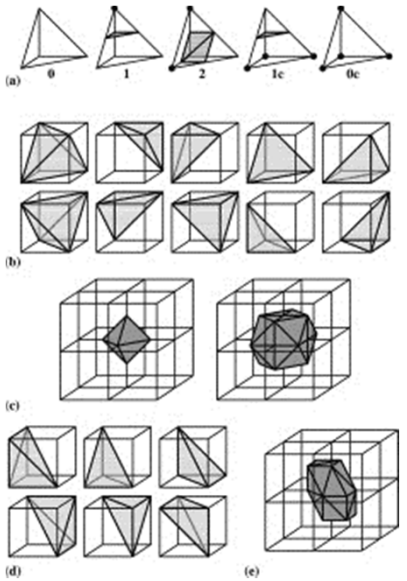


3D medical image

- Volume segmentation : iso-surface



2D

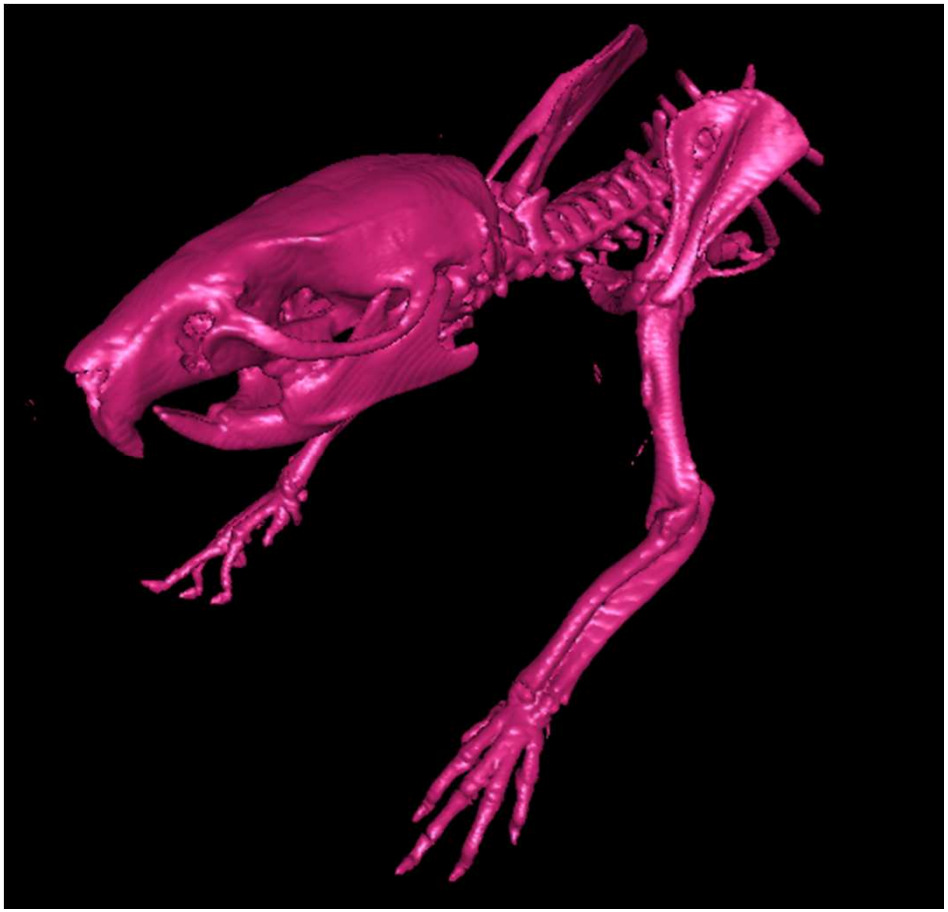


marching cube

3D

3D medical image

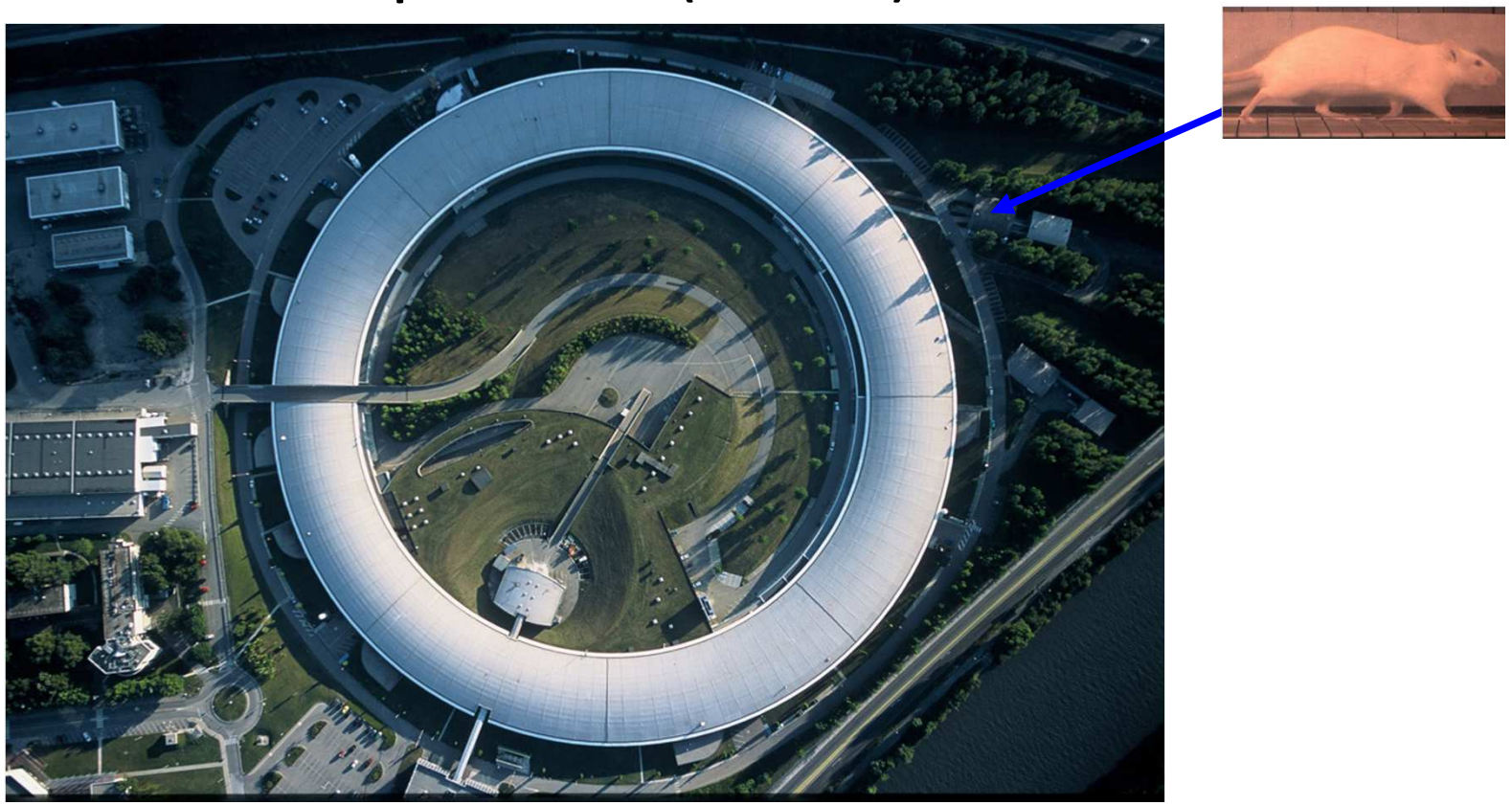
- Volume segmentation : iso-surface



demo: 3Dview

3D medical image

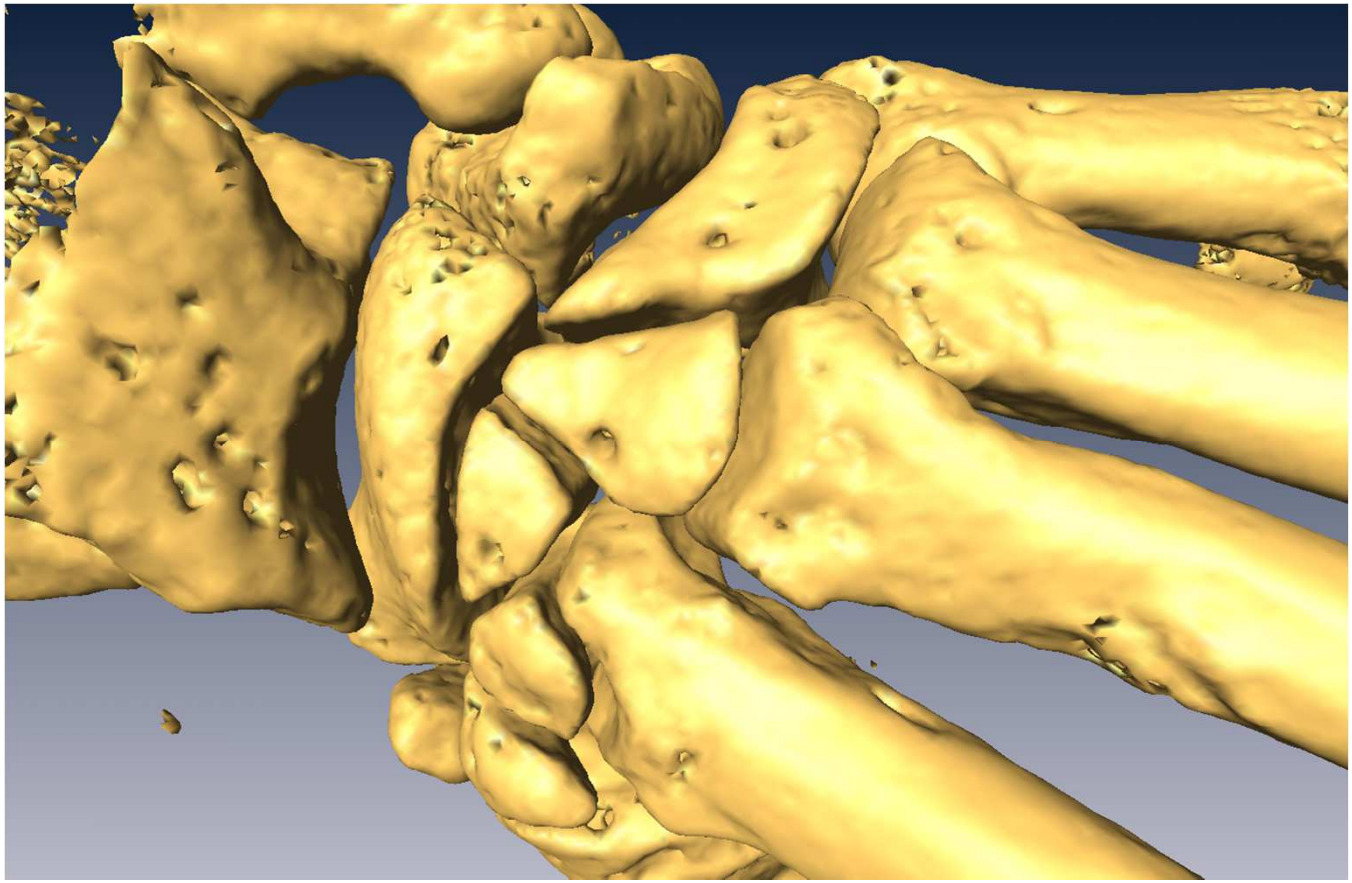
- With better acquisition (50um) …



European Synchrotron Radiation Facility, located in Grenoble

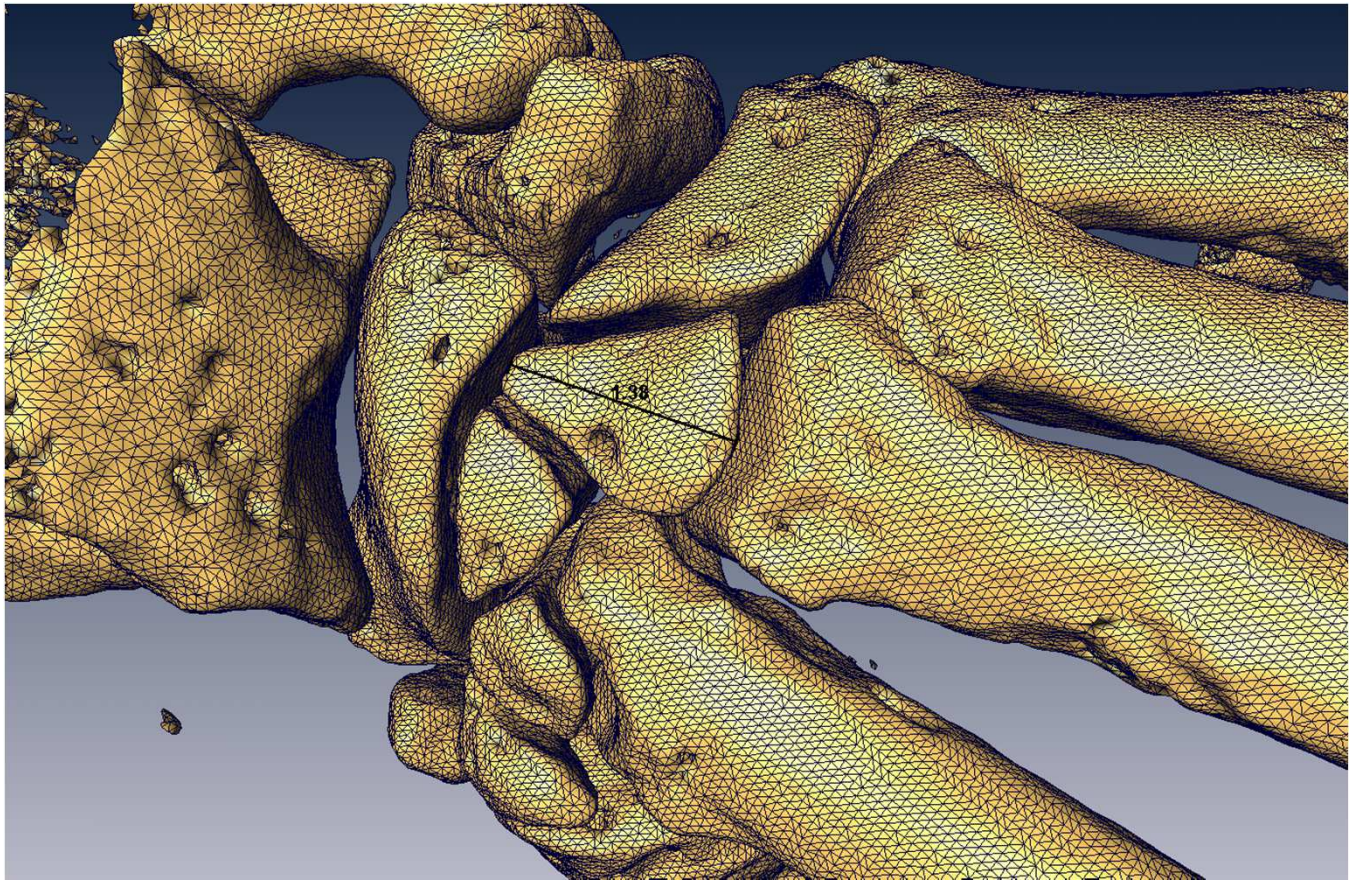
3D medical image

- … and software (AMIRA)



3D medical image

- … and software (AMIRA)



3D medical image

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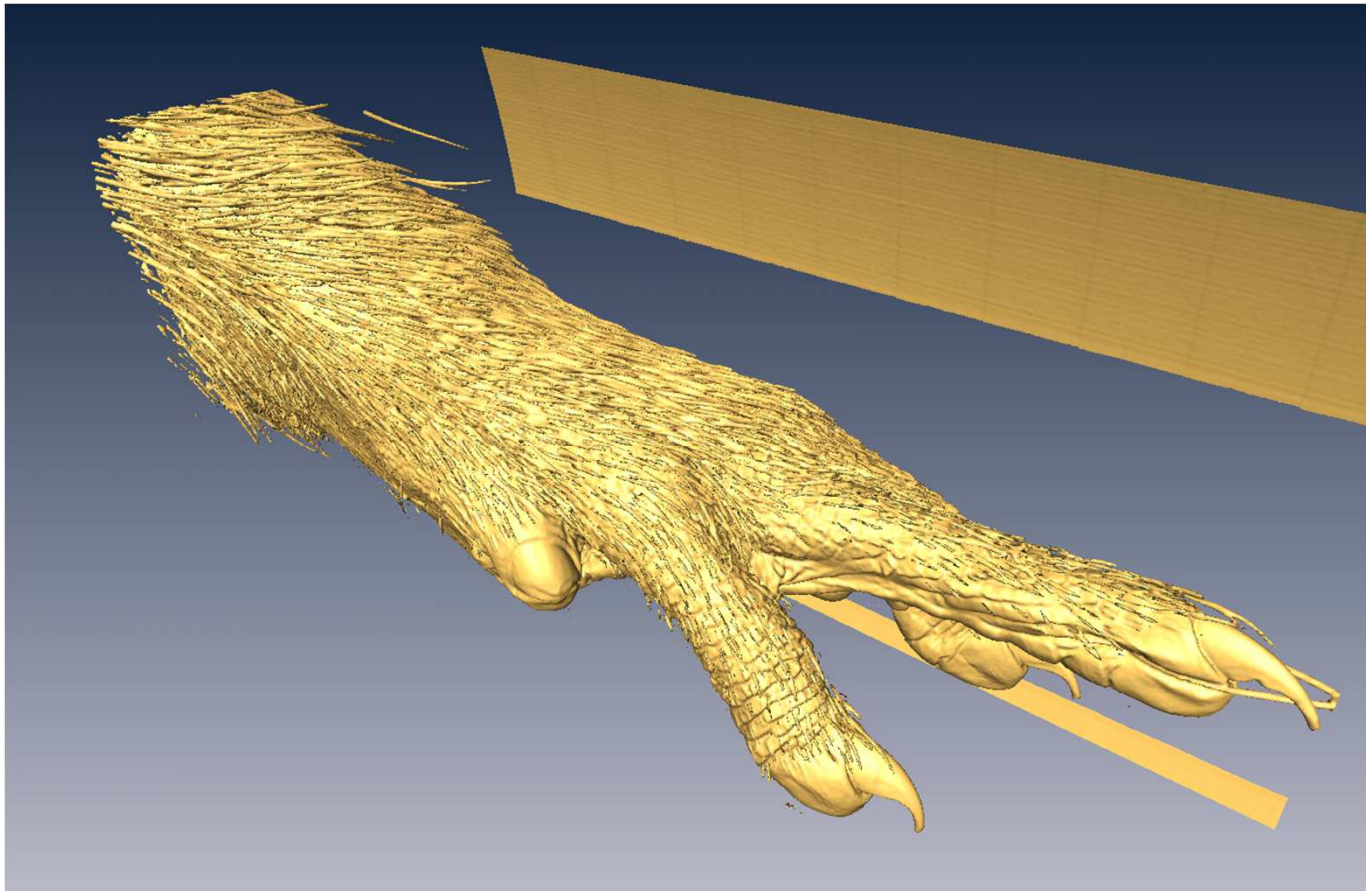
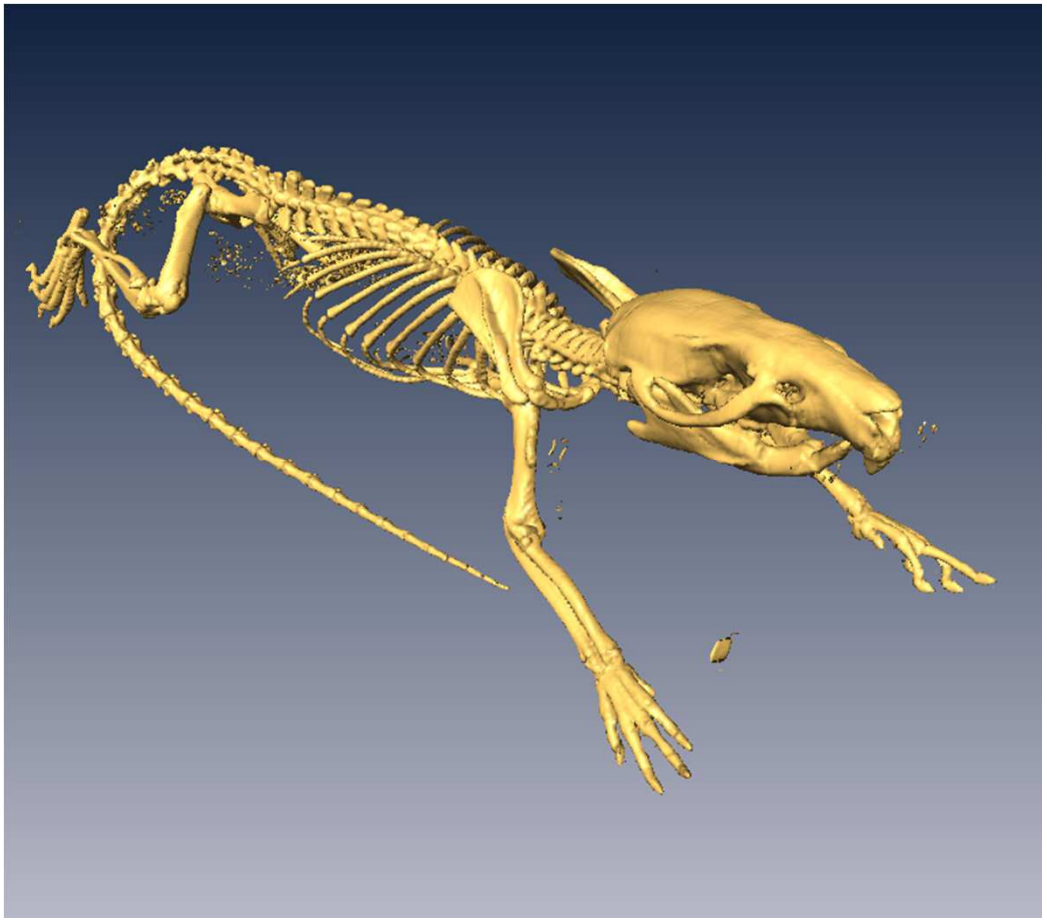


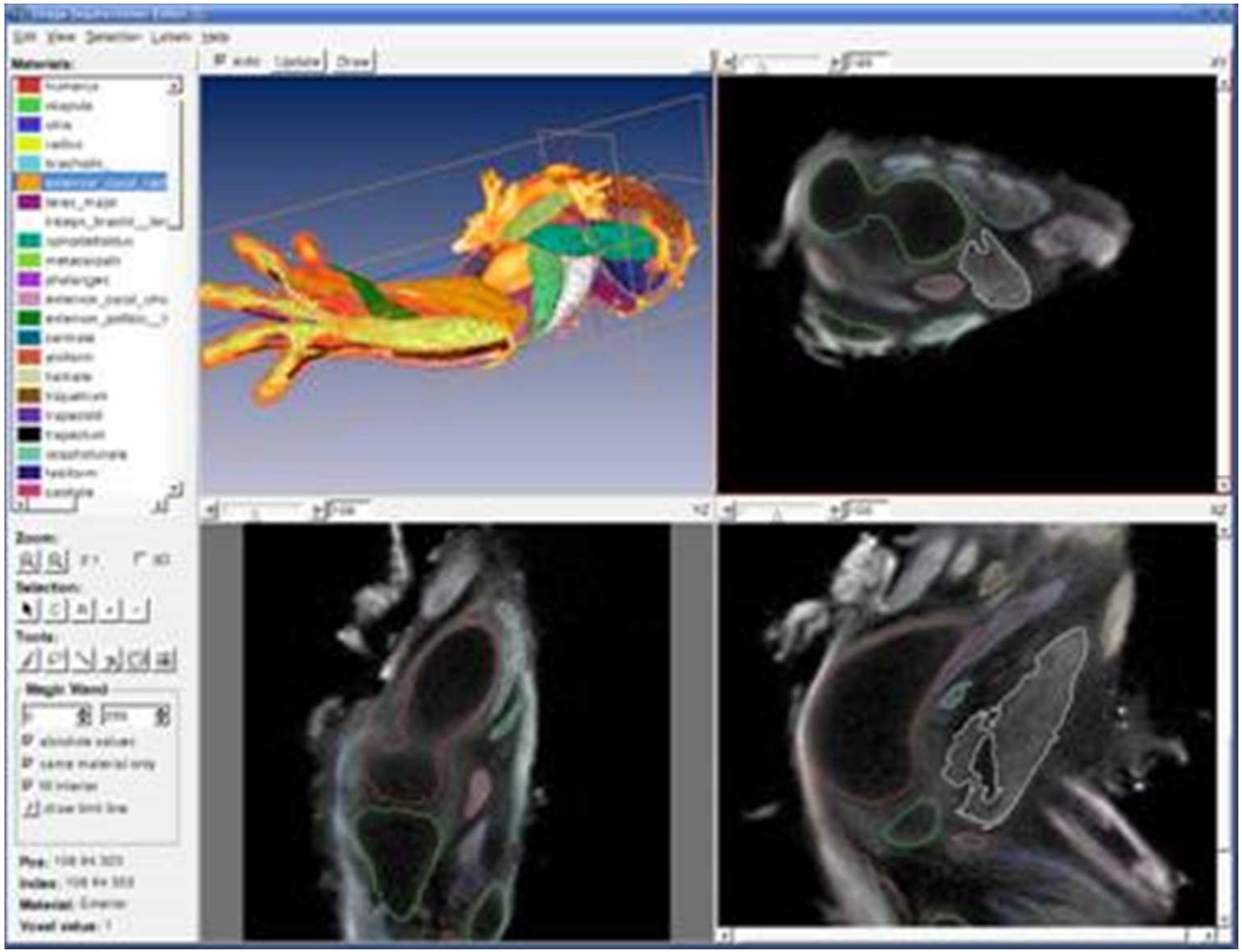
3D medical image

- … and software (AMIRA)



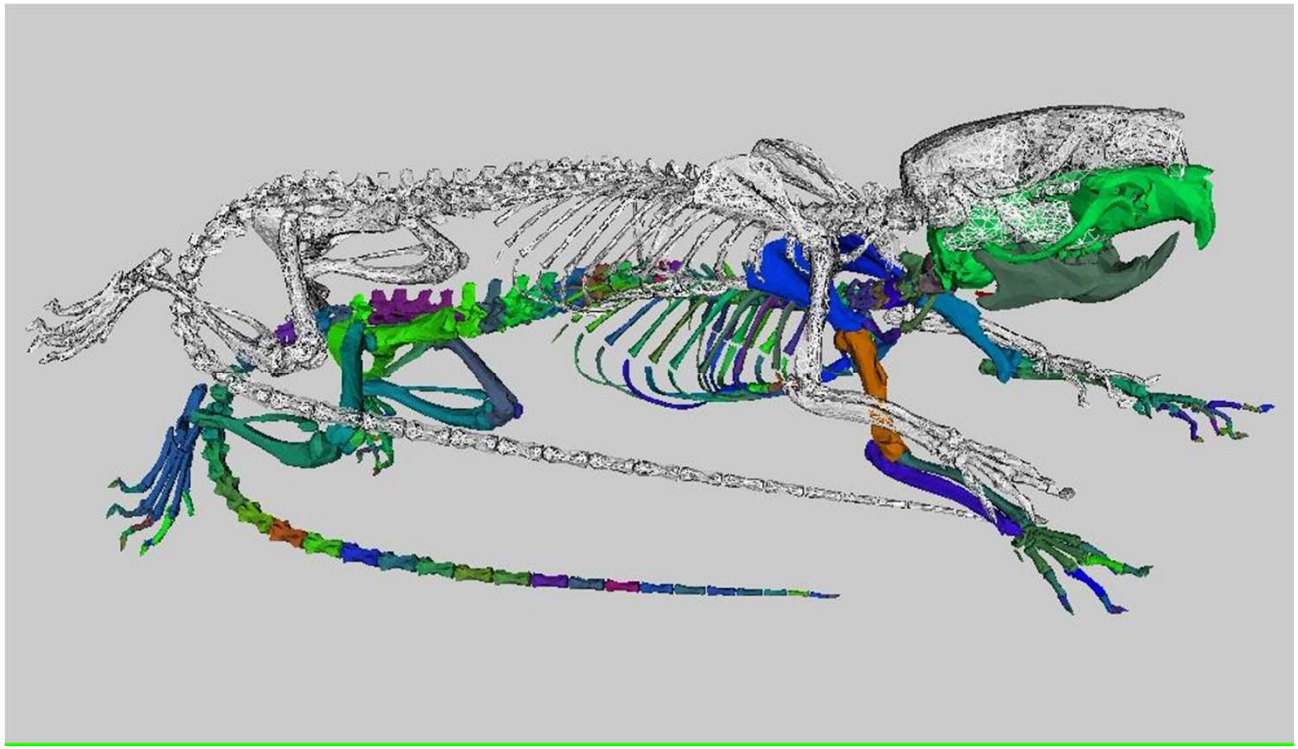
3D segmentation

- Labelling anatomical elements (semi-automatic)



3D segmentation

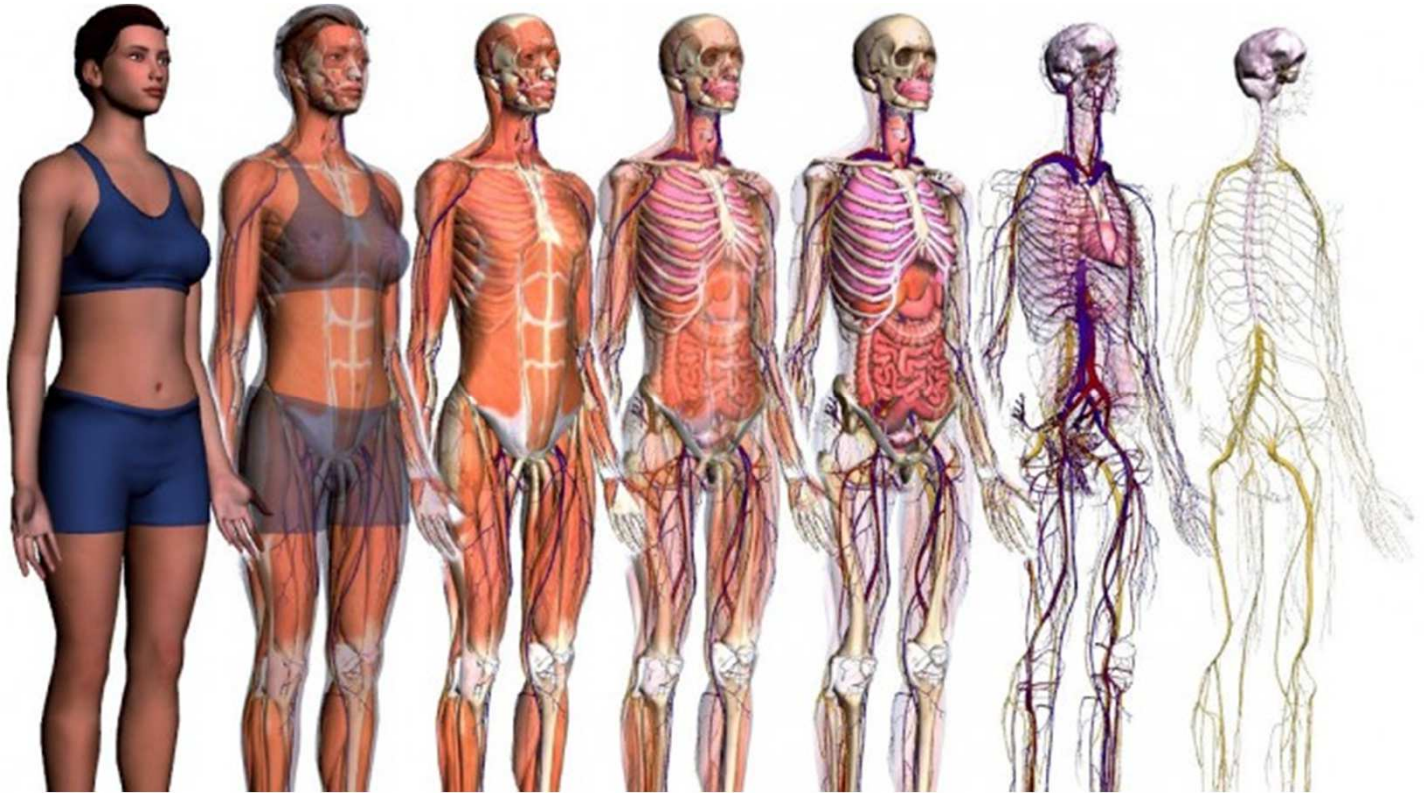
- Automatic segmentation



Gilles, Reveret, Pai, 2011

3D anatomical database

- Geometrical Atlas

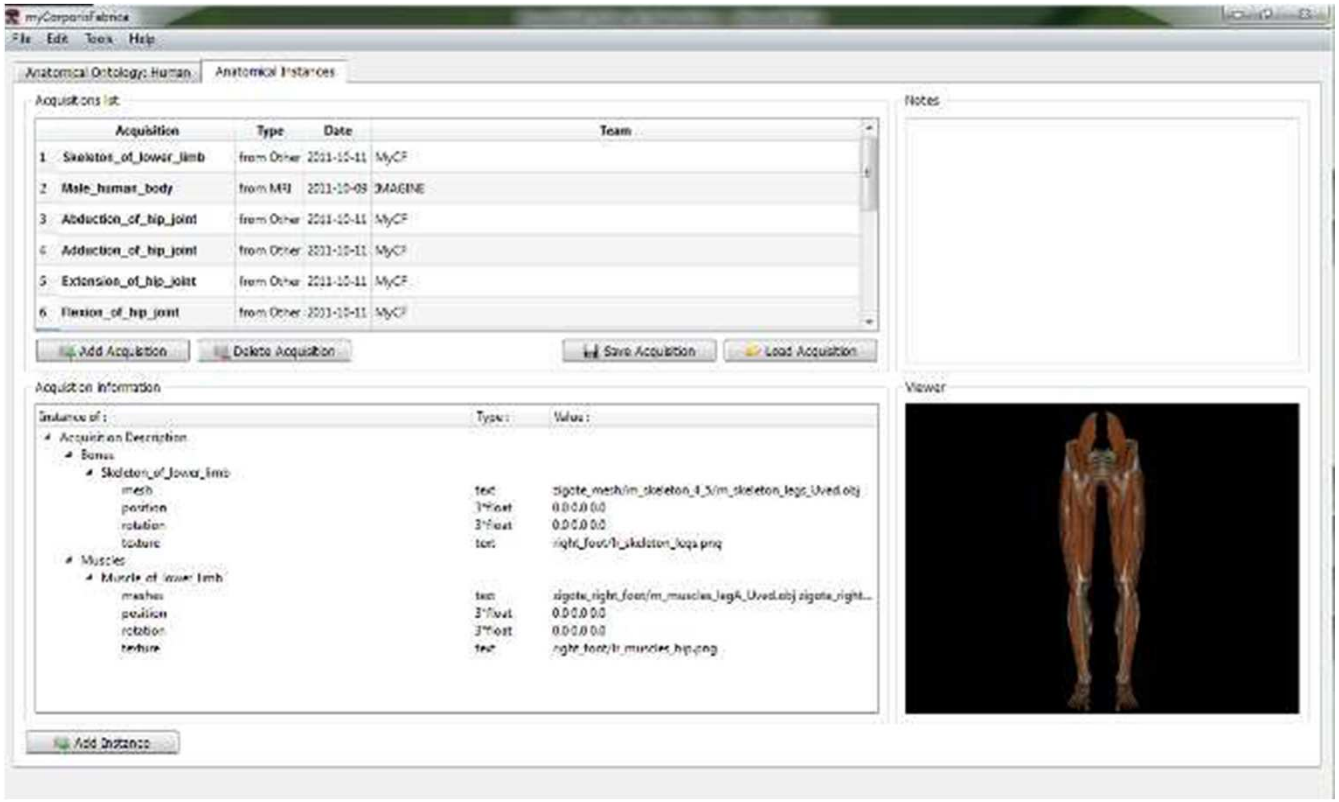


demo: maya-zygote, FK

© Zygote

3D anatomical database

- Geometry repository + Ontology



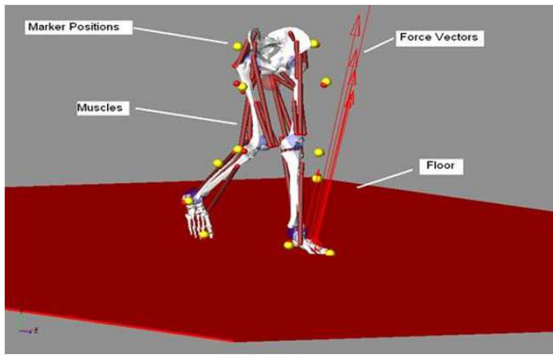
MyCorporisFabrica, O. Palombi

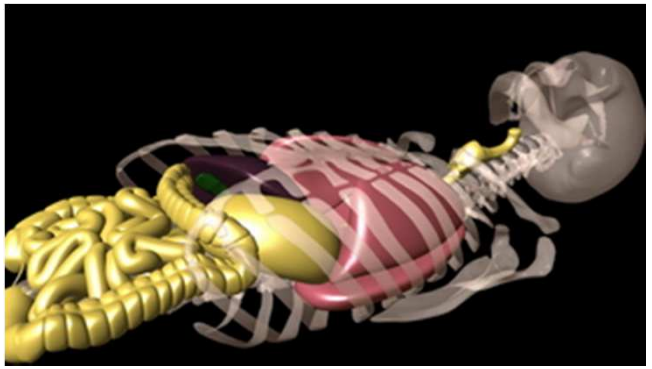
Part II – Anatomical Motion

Anatomical motion

- Measurement

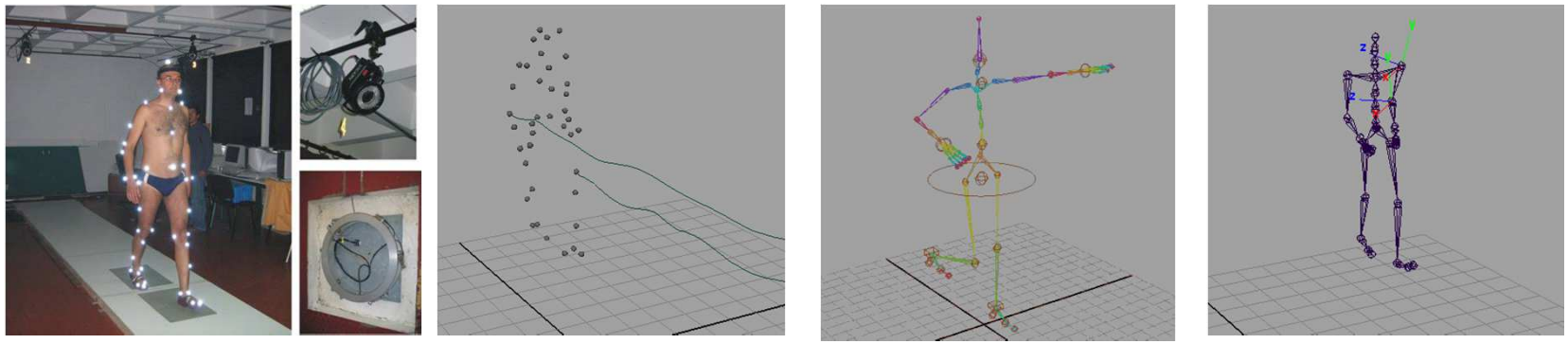
- Simulation





Articulatory motion

- From markers to rotational motion



- >=3 markers => direct rigid body trajectory
- <3 + constraints => Inverse Kinematics

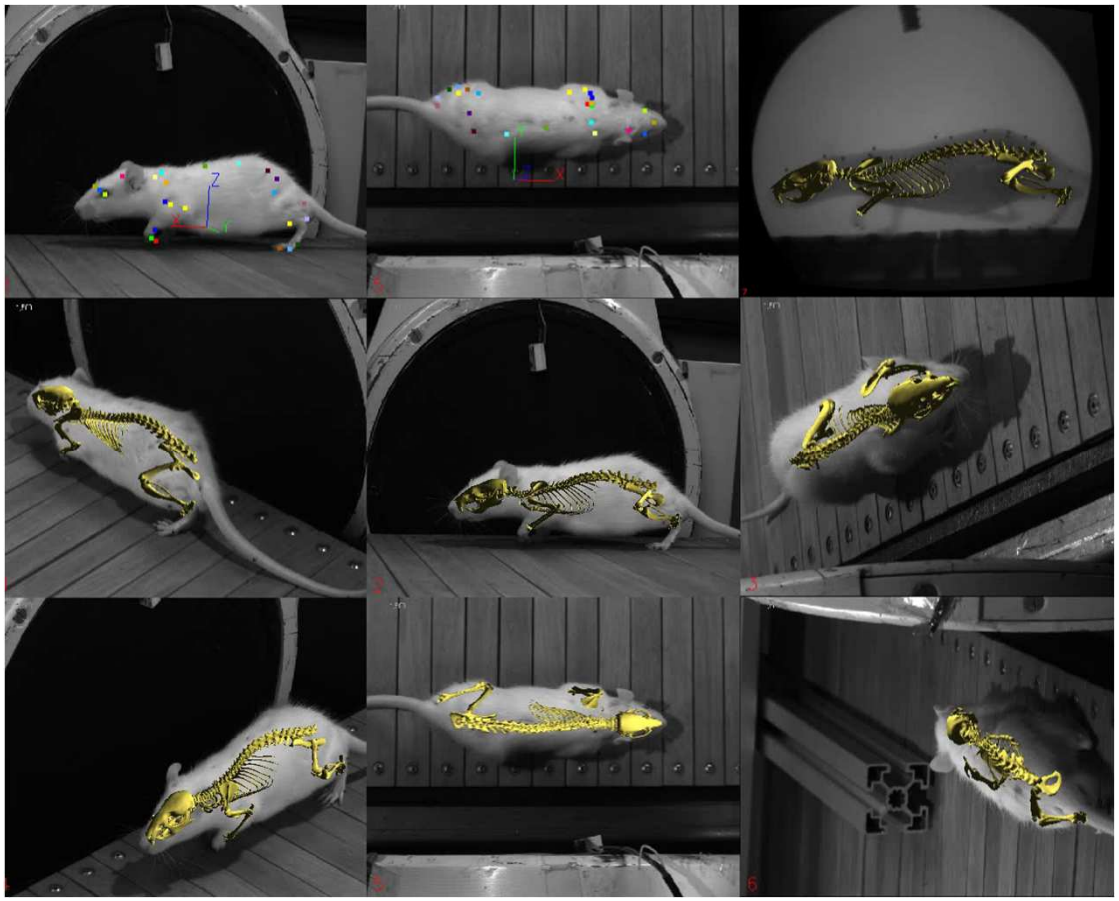
demo: Maya (IK, mocap)

Articulatory motion

- Problem of non-rigid coupling

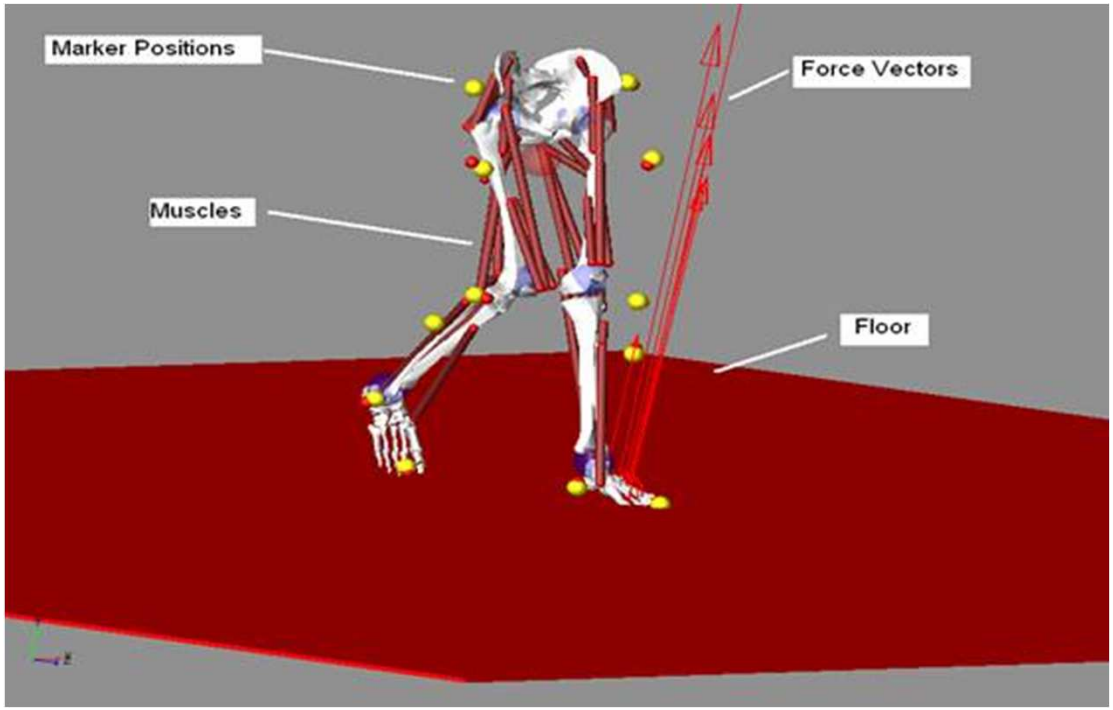
Articulatory motion

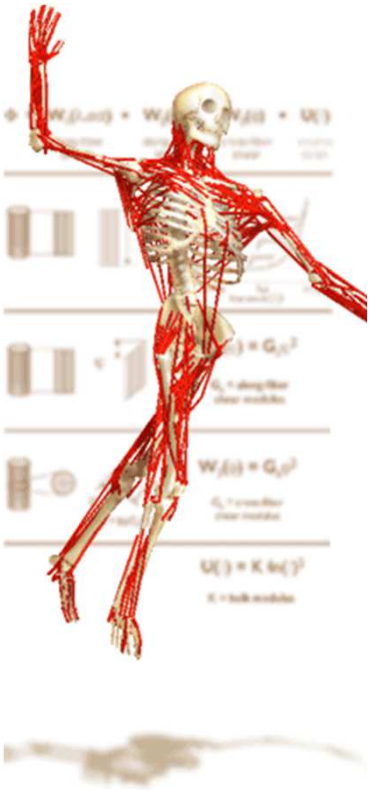
- Problem of non-rigid coupling



Inverse Dynamics

- From kinematics to muscle contraction

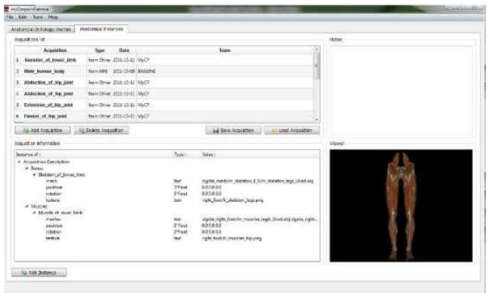


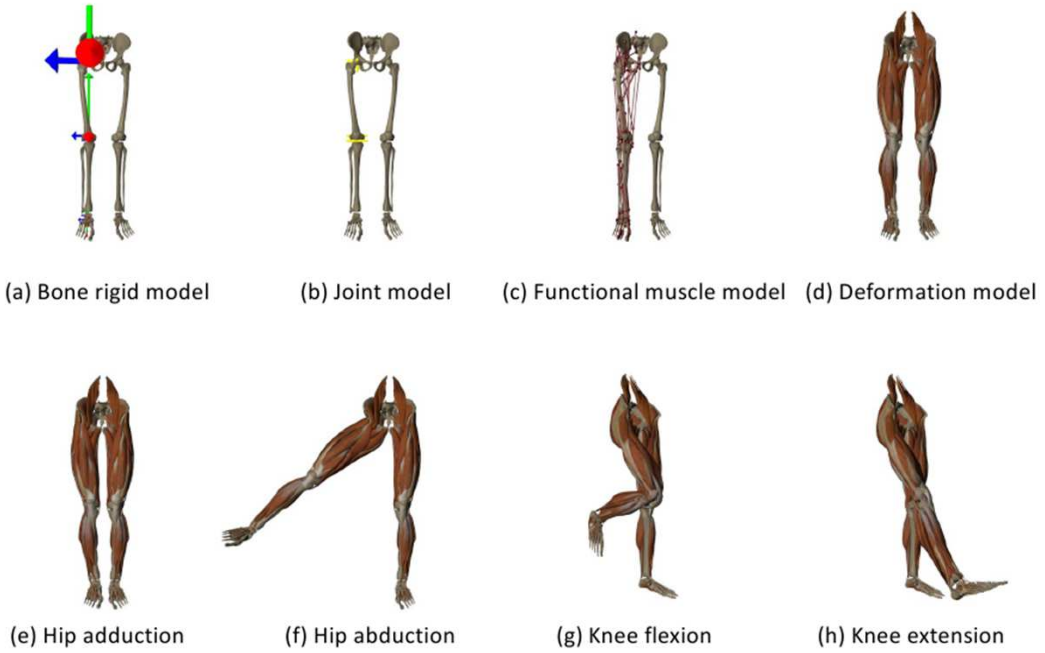


demo: OpenSim

Simulation

- From ontology to simulation

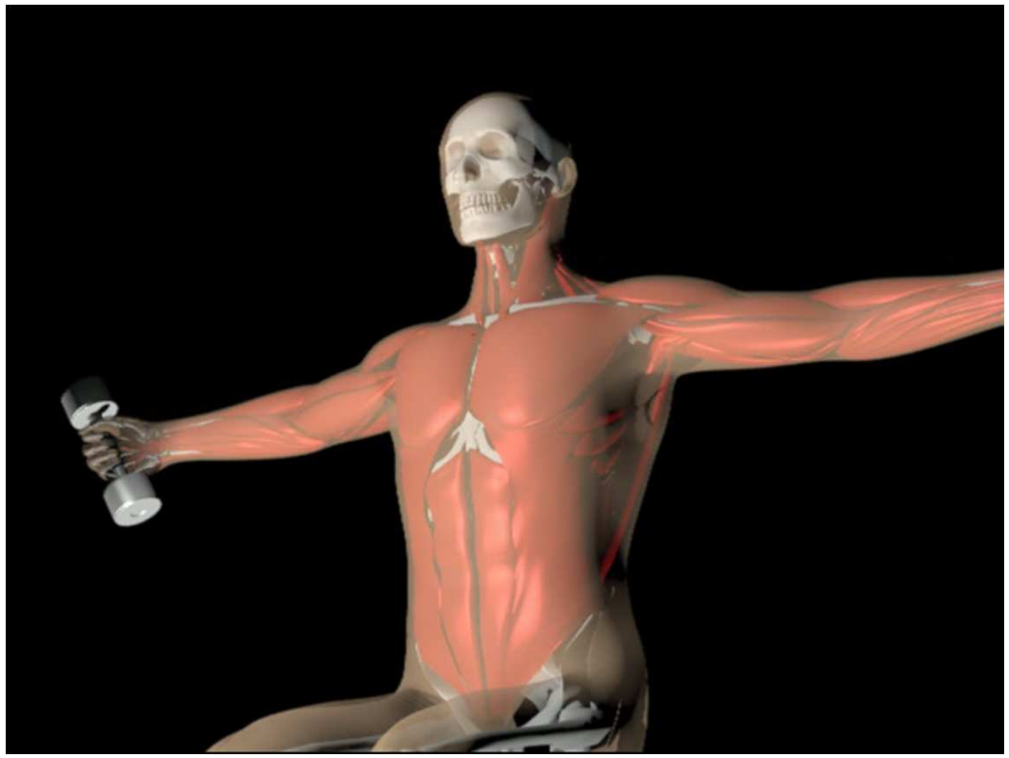




Dicko et al., 2011

Simulation

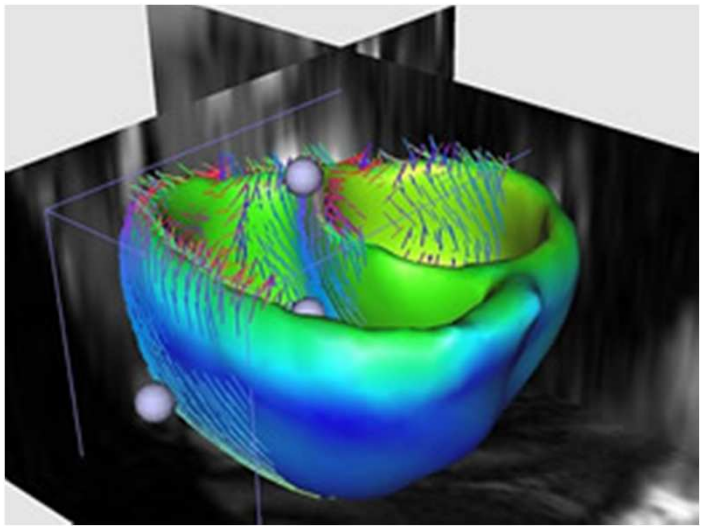
- Muscle as a deformable object



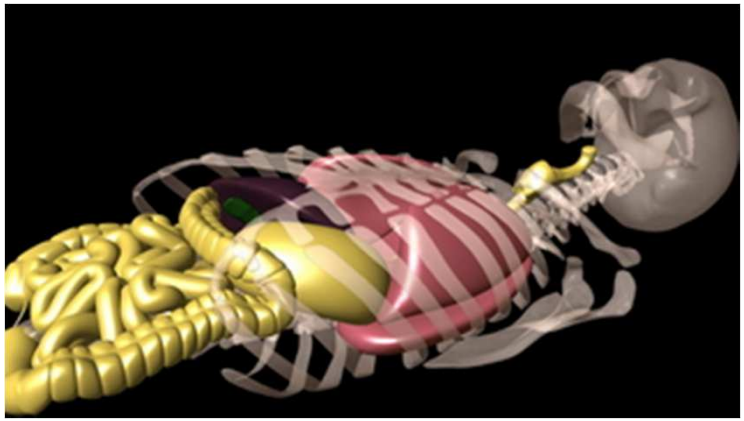
Lee, Sifakis, Terzopoulos, 2010

Simulation of organs

- Soft tissues



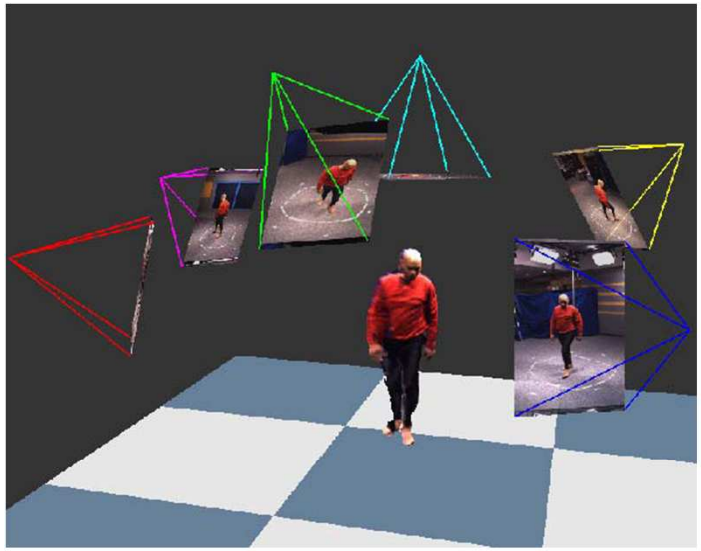
Cardiosense (INRIA)

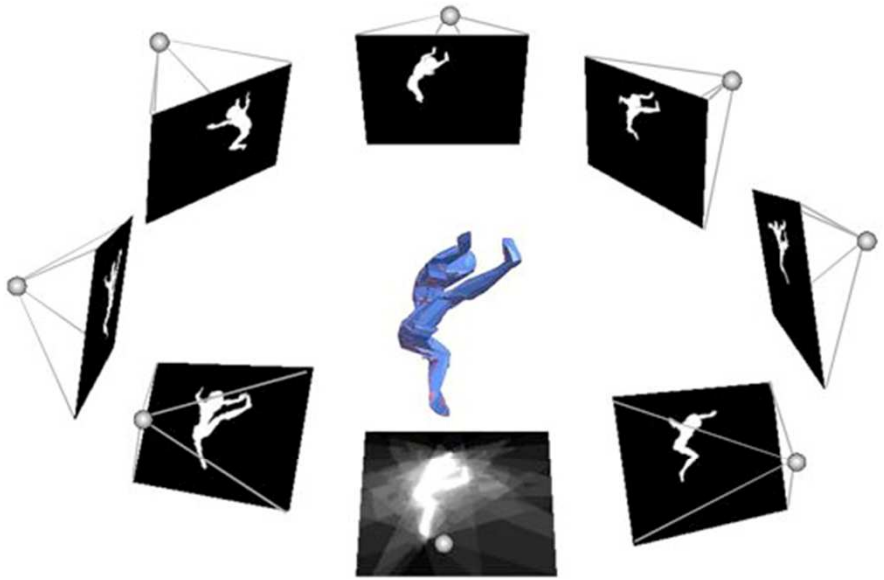


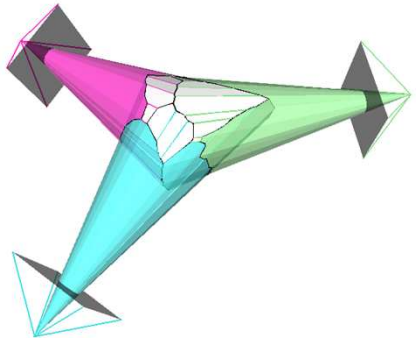
Challenges:
- whole body
- real-time interaction

New perspective

- Shape and motion acquisition

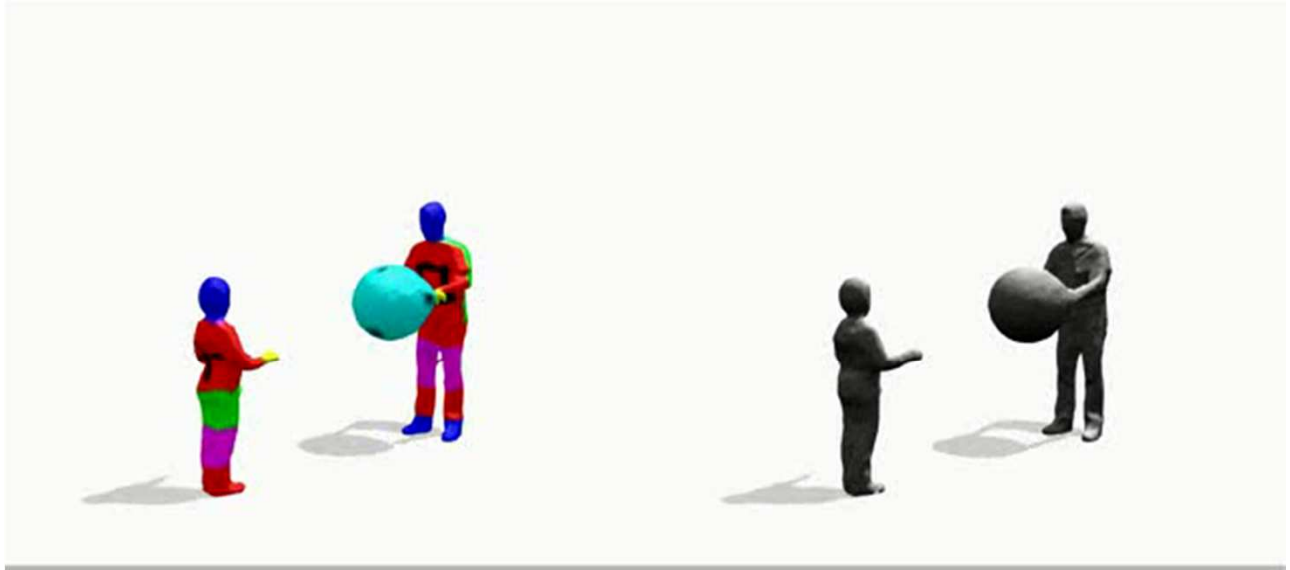






New perspectives

- Shape and motion acquisition

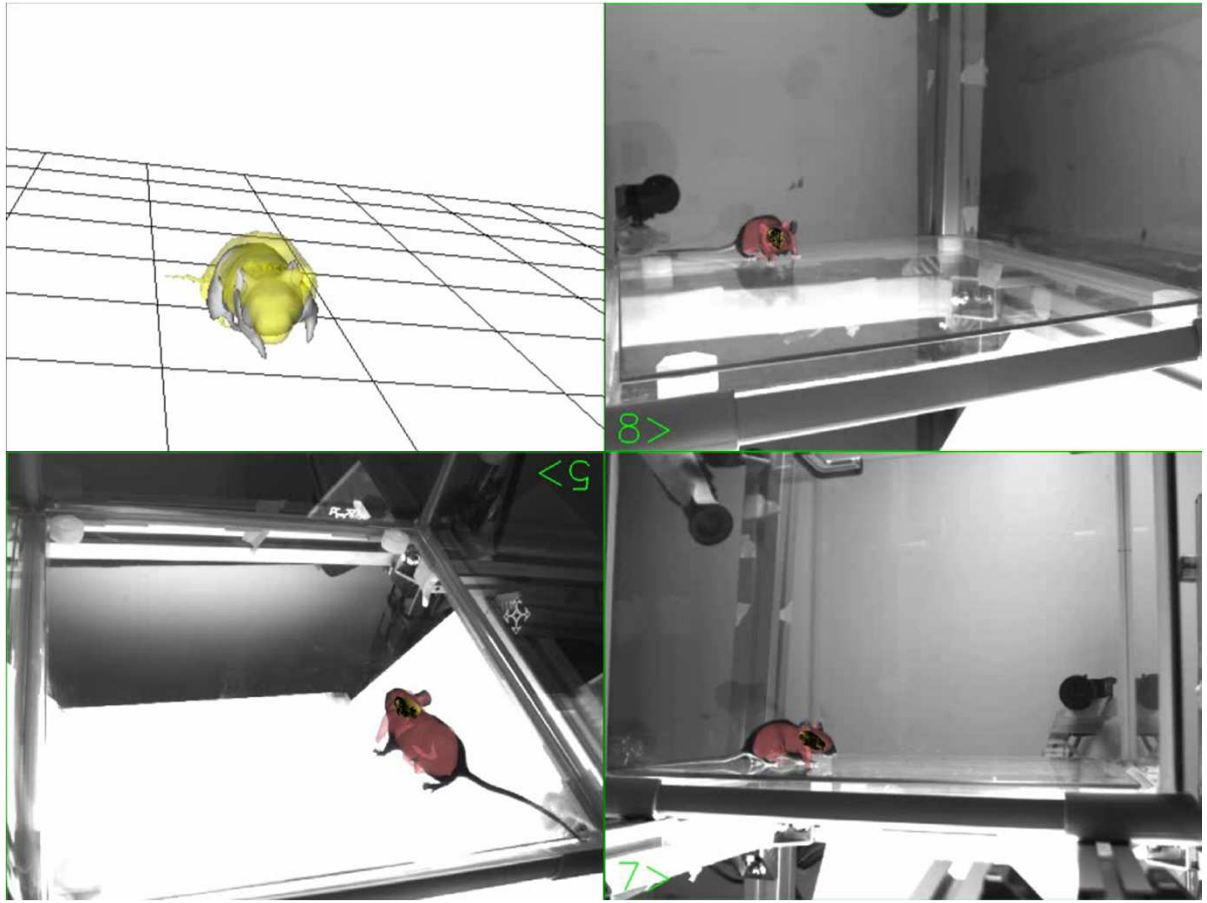


Ball sequence

source : INRIA

New perspectives

- Shape and motion acquisition



Conclusions

- Medical image
  - traditional clinical analysis from direct visualization
  - new tools by aligning 3D atlas
- Beyond static shape
  - integrate simulation for functional anatomy
  - shape and motion simultaneous acquisition