# Introduction to Computational Anatomy

lionel.reveret@inria.fr

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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

• Xray CT scanner (Computed Tomography)



#### Anatomy of a CT scan

CT scanners give doctors a 3-D view of the body. The images are exquisitely detailed but require a dose of radiation that can be 100 times that of a standard X-ray.



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#### • Xray CT scanner (Computed Tomography)



Demo : original and slice images

#### • Xray CT scanner : 3D texture rendering



• Xray CT scanner : enhancing visualization



A CT SCAN OF THE HEAD

Ray casting rendering



Radiocontrast agent

• MRI (Magnetic Resonnance Image)

- better vizualisation of muscles tissues





• Volume segmentation : iso-surface





**3D** 

• Volume segmentation : iso-surface



• With better acquisition (50um) ...





European Synchrotron Radiation Facility, located in Grenoble

**ESRF** 









## 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

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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

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(a) Bone rigid model



(f) Hip abduction





odel (c) Functional muscle model (d) Deformation model







(g) Knee flexion



(h) Knee extension

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



# 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