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
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
3D Medical image

- Xray CT scanner: enhancing visualization

Ray casting rendering

Radiocontrast agent
3D Medical image

- MRI (Magnetic Resonance Image)
  - better visualization of muscles tissues
3D medical image

• Volume segmentation: iso-surface

2D

boundary

3D

marching cube
3D medical image

- Volume segmentation: iso-surface
3D medical image

• With better acquisition (50um) ...
3D medical image

• ... and software (AMIRA)
3D medical image

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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
3D anatomical database

- Geometry repository + Ontology

MyCorporisFabrica, O. Palombi
Part II – Anatomical Motion
Anatomical motion

• Measurement

• Simulation
Articulatory motion

- From markers to rotational motion

- $\geq 3$ markers $\Rightarrow$ direct rigid body trajectory
- $< 3 +$ constraints $\Rightarrow$ 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

(a) Bone rigid model  (b) Joint model  (c) Functional muscle model  (d) Deformation model
(e) Hip adduction  (f) Hip abduction  (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