A semantic-driven platform for musculoskeletal simulation

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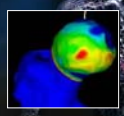
Projects

MIRALab research on medical simulation since years

- 1993 CHARM *Comprehensive Human Animation Resource Model*
- 1996 MIAS *Minimally Invasive Articular Surgery*
- 1996 TREMOR *Development and validation of new assistive devices for treatment of disability caused by TREMOR*
- 1998 DRAMA *Developments in Rehabilitation of the Arm*

Projects

MIRALab research on medical simulation since years



- 2001 Co-Me *Interactive clinical visualization for hip joint examination, Swiss National project*
- 2006 3D Anatomical Human
  3D anatomical functional models for the human musculoskeletal system, European Project

3D Anatomical Human

Marie Curie RTN
8 partners (MIRALab, IOR, UCL, INRIA, STARLab, SMI, EPFL, CRS4)
Goals

- **Develop** realistic functional musculoskeletal models of the lower limbs
  - Integrated model (anatomy + dynamics + physiology)
- **Unfold** new technologies and knowledge around virtual representations of human body
  - Combine knowledge on the human musculoskeletal system
- **Improve** the learning support for medical training
  - Dynamic atlases

CO-ME

Subproject of the Swiss NCCR

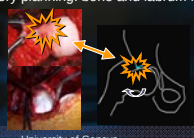
5 partners (MIRALab, EPFL, MEM Center, HUG, INSELSPITAL Bern)

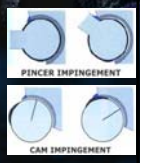
Goal: early detection of hip osteoarthritis (hip joint degeneration)

Improve understanding:
- Cause: repetitive femoro-acetabular impingement (FAI) ?
  -> This hypothesis need to be demonstrated through clinical studies

Improve detection:
- Support early diagnosis
- More automatic and objective assessment

Improve treatment (minimally invasive surgery):
- Support corrective surgery planning: bone and labrum resection
- Support arthroscopy

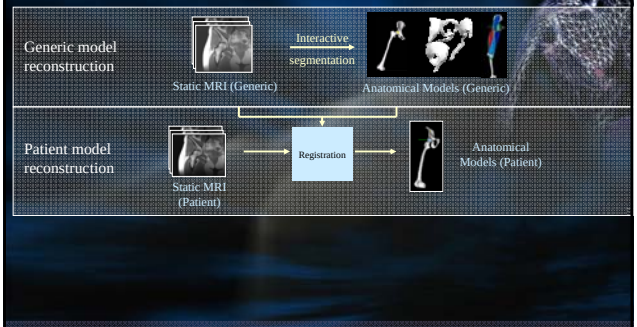




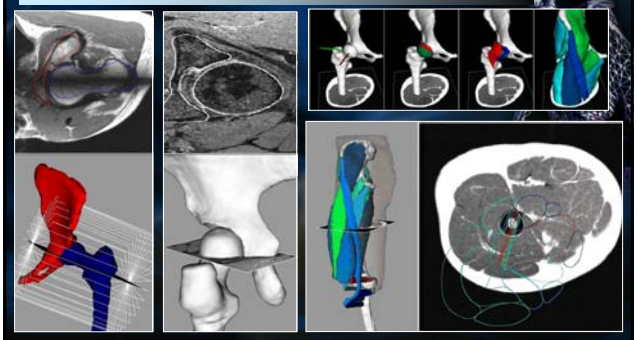
Outline

- Introduction
- Current medical ontology development
- A semantic-driven platform
  - The Ontology For Anatomical Simulation (OFAS) model
  - System overview
- Scenarios

Modeling of the musculoskeletal system from MRI



Modeling of the musculoskeletal system from MRI



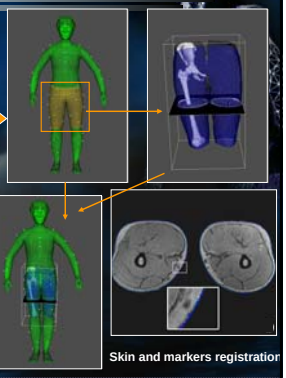
4 Bones **3 Cartilages, 3 Ligaments** **21 Muscles**

Motion modeling

Body scanning

Determination of the bone segments in the marker cluster technical frame:

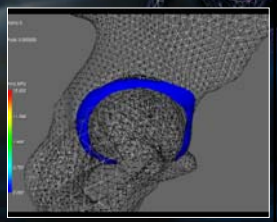
3D body scanning



Skin and markers registration

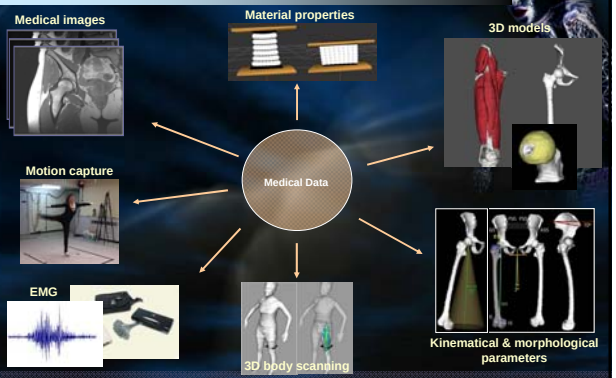
Physical-based simulation

- Simulator:
  - Based on particles system implementation of FE
  - Optimizes for large deformations
  - Accurate and fast
- Biomechanical modeling:
  - Hip + femur bones (rigid)
  - Labrum cartilage (deformable)
    - Young's modulus: 20 MPa
    - Poisson's ratio: 0.4



The complete pipeline

Medical data



Needs

More user-centric systems

that act as

"intelligent" assistants,

able to

centralize the data,

and to

interact naturally with human users and with the information environment.

What knowledge?

- The terminologies commonly used by clinicians
  - Anatomy
  - Physiology
  - Pathology, etc.
- Available from:
  - Medical atlases
  - Medical literature
  - Medical discourse, etc.

Why do we need ontology?

- For information management
- To share common understanding of the structure of information among people or software agents
- To enable reuse of domain knowledge
- To analyze domain knowledge

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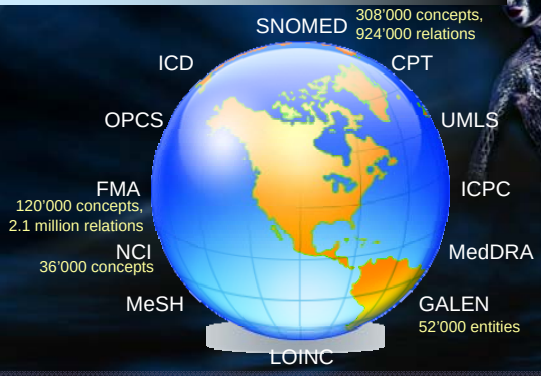
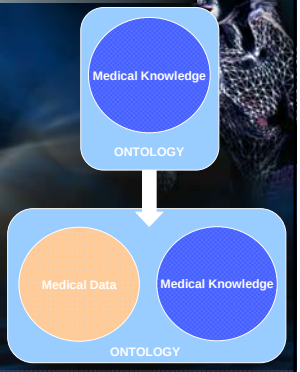
The world of medical ontologies



Current medical ontology development

- Aims:
  - Biological databases, medical record, health insurance, clinical billing, indexing, …
- What next?
  - Develop end user applications
  - Build the links with the medical data and the 3D content



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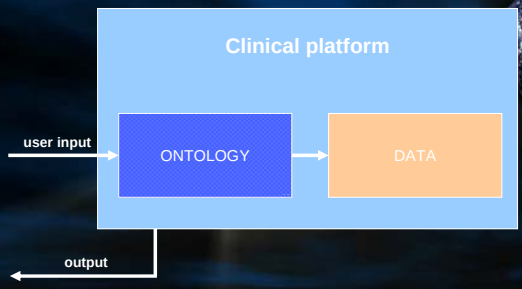
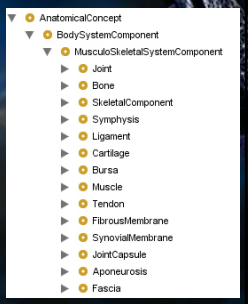
The clinical platform



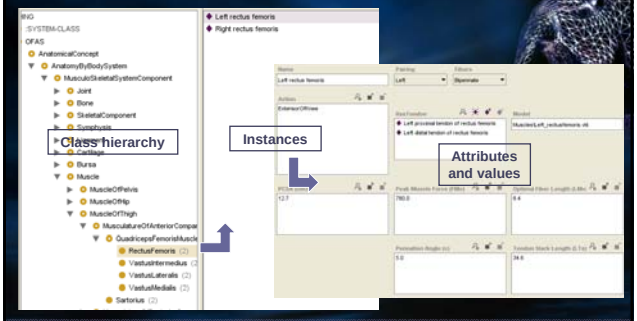
The OFAS model

- Classification of anatomical musculoskeletal concepts
  - 825 classes, 1244 instances
- Contains parameters for the functional anatomy simulation (kinematics, mechanics)
- All concepts are linked to a 3D model
- Limited to the musculoskeletal system of the lower limb



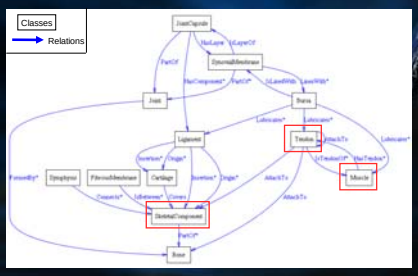
The OFAS model

- Structure (in Protégé):



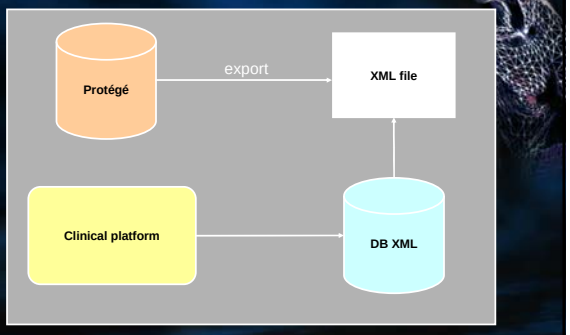
The OFAS model

- Relations between classes



Example: A muscle has a tendon which is attached to a bone (skeletal component).

System overview



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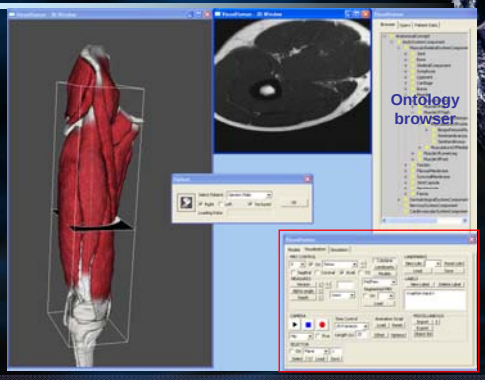

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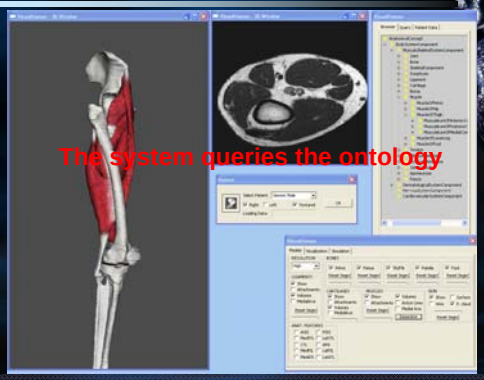
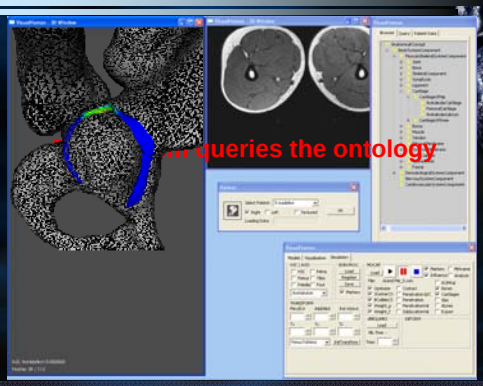
Scenario 1: visualization



Scenario 2: simulation



Scenario 3: medical training

Acknowledgments

CO-ME
COMPUTER AIDED AND IMAGE GUIDED MEDICAL INTERVENTIONS

Computer Aided and Image Guided Medical Interventions), Swiss national project
www.co-me.ch

FOCUS K3D

FOster the Comprehension and USe of Knowledge intensive technologies for coding and sharing 3D media content, EU project (FP7)
www.focusk3d.eu

Thank you!

Questions?