



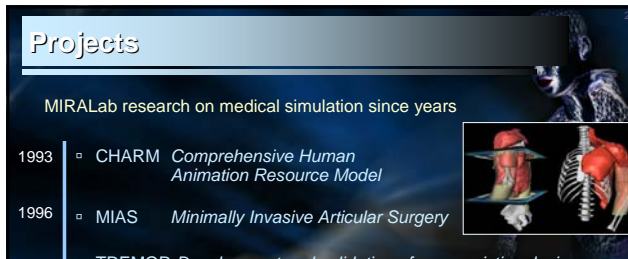
A semantic-driven platform for musculoskeletal simulation

Caecilia Charbonnier
MIRALab – University of Geneva

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch



WAM 2009
16th June 2009



Projects

MIRALab research on medical simulation since years

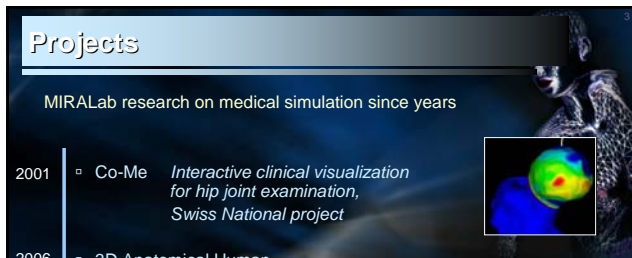
- 1993 ▫ CHARM *Comprehensive Human Animation Resource Model*
- 1996 ▫ MIAS *Minimally Invasive Articular Surgery*
- 1996 ▫ TREMOR *Development and validation of new assistive devices for treatment of disability caused by TREMOR*
- 1998 ▫ DRAMA *Developments in Rehabilitation of the Arm*
- ⋮

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

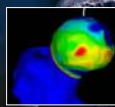
WAM 2009
16th June 2009



Projects

MIRALab research on medical simulation since years

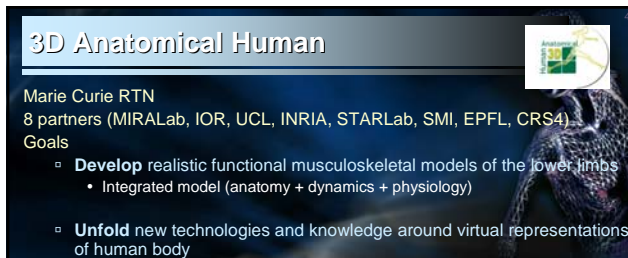
- 2001 ▫ Co-Me *Interactive clinical visualization for hip joint examination, Swiss National project*
- 2006 ▫ 3D Anatomical Human *3D anatomical functional models for the human musculoskeletal system, European Project*
- ⋮



MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009




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



MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

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



MIRALab
 Where Research Means Creativity

University of Geneva
 www.miralab.ch

WAM 2009
 16th June 2009

Outline

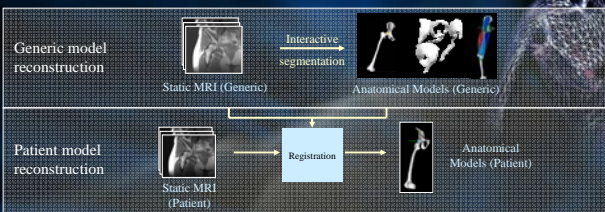
- Introduction
- Current medical ontology development
- A semantic-driven platform
 - The Ontology For Anatomical Simulation (OFAS) model
 - System overview
- Scenarios

MIRALab
 Where Research Means Creativity

University of Geneva
 www.miralab.ch

WAM 2009
 16th June 2009

Modeling of the musculoskeletal system from MRI



Generic model reconstruction: Static MRI (Generic) → Interactive segmentation → Anatomical Models (Generic)

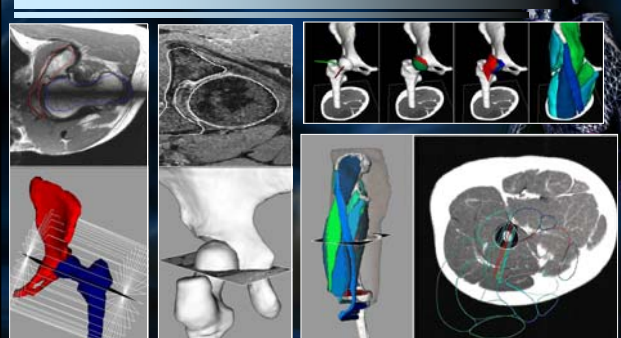
Patient model reconstruction: Static MRI (Patient) → Registration → Anatomical Models (Patient)

MIRALab
 Where Research Means Creativity

University of Geneva
 www.miralab.ch

WAM 2009
 16th June 2009

Modeling of the musculoskeletal system from MRI



4 Bones 3 Cartilages, 3 Ligaments 21 Muscles

MIRALab
 Where Research Means Creativity

University of Geneva
 www.miralab.ch

WAM 2009
 16th June 2009

Motion modeling

The slide shows a person in a motion capture studio on the left and a skeletal model on the right. The skeletal model is a white wireframe of a human skeleton with markers at various joints.

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

Body scanning

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

The slide illustrates the process of 3D body scanning. On the left, a person is shown in a scanning environment. An arrow points to a 3D model of a person. Another arrow points to a technical frame showing the determination of bone segments. A final arrow points to a 3D model with skin and markers registration, which includes cross-sectional images of the body.

3D body scanning

Skin and markers registration

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

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 slide features two images: a 3D simulation of a hip joint showing stress distribution on the labrum cartilage, and a cross-sectional view of the hip joint with a blue ring representing the labrum cartilage.

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

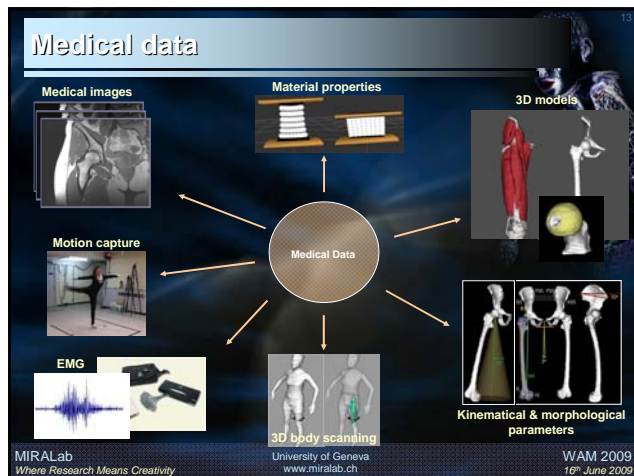
The complete pipeline

The slide shows a 3D model of a person lying down, representing the complete pipeline from scanning to simulation.

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009



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.

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

What knowledge?

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

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

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

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

Outline

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

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

The world of medical ontologies

Ontology	Concepts	Relations	Entities
SNOMED	308'000	924'000	-
ICD	-	-	-
CPT	-	-	-
UMLS	-	-	-
ICPC	-	-	-
MedDRA	-	-	-
GALEN	-	-	52'000
LOINC	-	-	-
MeSH	-	-	-
NCI	36'000	-	-
FMA	120'000	2.1 million	-
OPCS	-	-	-

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

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

The diagram illustrates the integration of Medical Knowledge and Medical Data. At the top, a blue circle labeled 'Medical Knowledge' is connected to a larger blue circle labeled 'Medical Knowledge' which sits on top of a light blue rounded rectangle labeled 'ONTOLOGY'. Below this, another light blue rounded rectangle labeled 'ONTOLOGY' contains two circles: an orange one labeled 'Medical Data' and a blue one labeled 'Medical Knowledge'. A white arrow points from the top 'ONTOLOGY' box down to the bottom 'ONTOLOGY' box, indicating the flow of information or the application of the ontology to data.

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

Outline

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

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

The clinical platform

The clinical platform is a system where user input is processed through an ontology and data components to produce an output.

MIRALab
Where Research Means Creativity
University of Geneva
www.miralab.ch
WAM 2009
16th June 2009

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

MIRALab
Where Research Means Creativity
University of Geneva
www.miralab.ch
WAM 2009
16th June 2009

The OFAS model

- Structure (in Protégé):

The structure in Protégé includes a class hierarchy, a list of instances, and a detailed view of an instance's attributes and values.

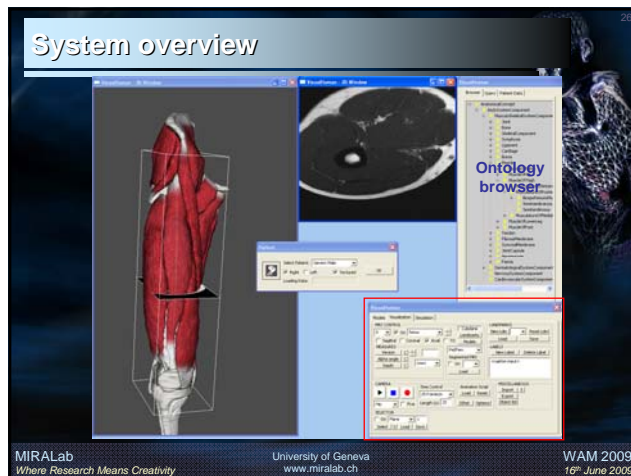
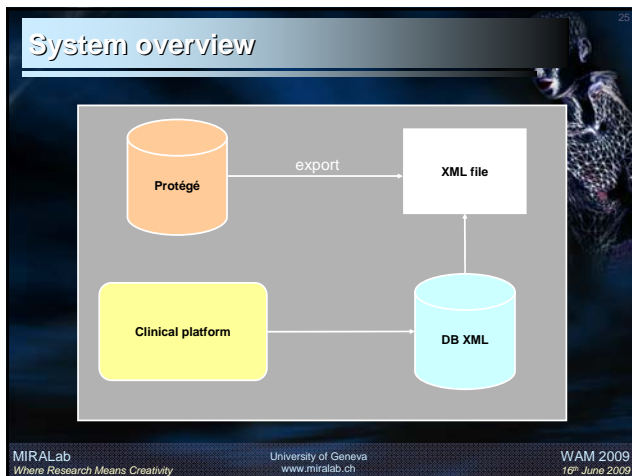
MIRALab
Where Research Means Creativity
University of Geneva
www.miralab.ch
WAM 2009
16th June 2009

The OFAS model

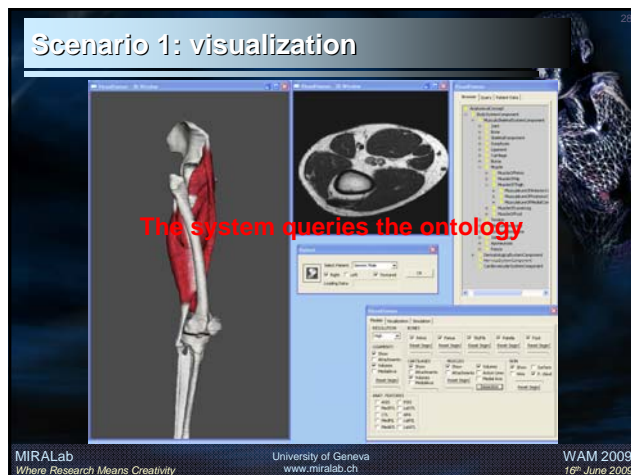
- Relations between classes

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

MIRALab
Where Research Means Creativity
University of Geneva
www.miralab.ch
WAM 2009
16th June 2009



- ### Outline
- Introduction
 - Current medical ontology development
 - A semantic-driven platform
 - The Ontology For Anatomical Simulation (OFAS) model
 - System overview
 - Scenarios
- MIRALab
Where Research Means Creativity
- University of Geneva
www.miralab.ch
- WAM 2009
16th June 2009



Scenario 2: simulation

...queries the ontology

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

Scenario 3: medical training

The system queries the ontology

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

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

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009

Thank you!

Questions?

MIRALab
Where Research Means Creativity

University of Geneva
www.miralab.ch

WAM 2009
16th June 2009