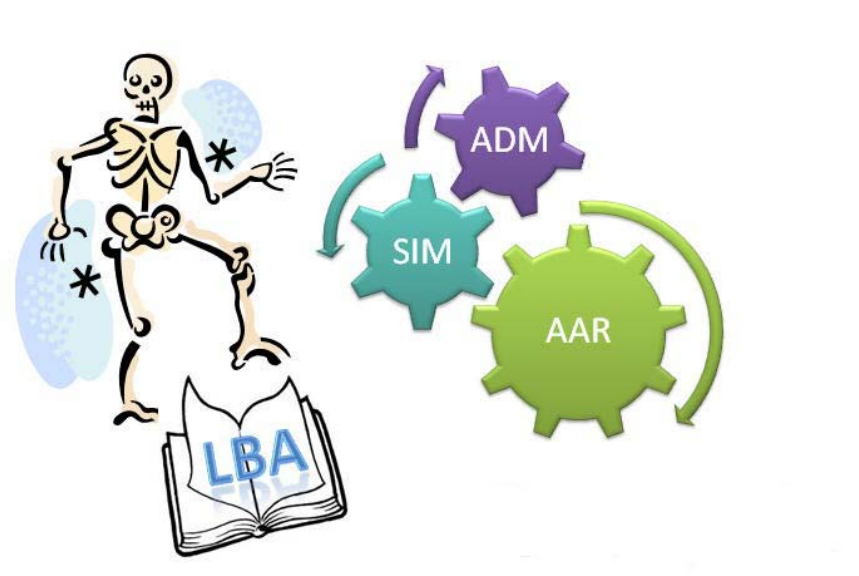
The Living Book of Anatomy



gipsa-lab

L I G

TIMC

Inria

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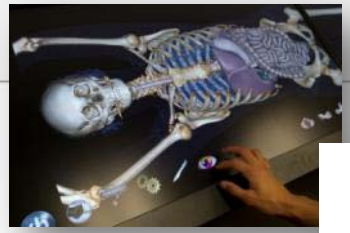
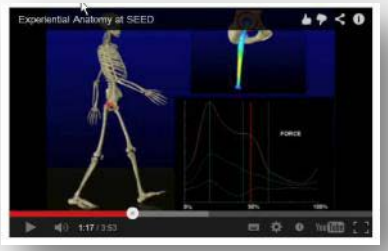
Learning anatomy

- Anatomical knowledge includes a large amount of structured, static and dynamic notions
- It is still learnt through atlases, books, dissection
- Learning could benefit from the use of emerging technology and augmented reality
- Hypothesis: using his/her own body may help the trainee to better understand dynamic notions

Short state of the art



- Visible Human Project
- Virtual Physiological Human
- Virtual dissection (Anatomage®)
- Medical augmented reality [Navab et al], VH dissector (MacLennan Comm College)
- Embodiment
  - Somatic learning [Freller2008]
  - « experiential anatomy »



Already a lot of available data

System
- IPad
- IPhone
- Mac
- PC
- **Browsers**
  - Firefox
  - Google Chrome

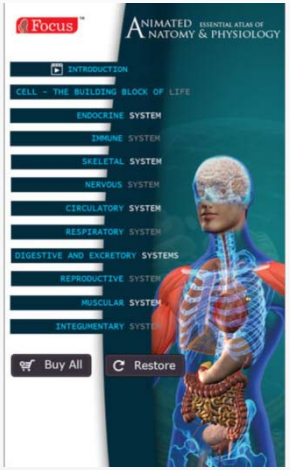
Objective
- **Learning**
  - Doctor
  - Sport educ
  - Physiotherapist
  - Other
- **Enhanced training**
  - Doctor
  - Sport educ
  - Physiotherapist
  - Other
- Aiding in the medical diagnosis
- Aiding in the medical procedure
- Sports activity / Leisure

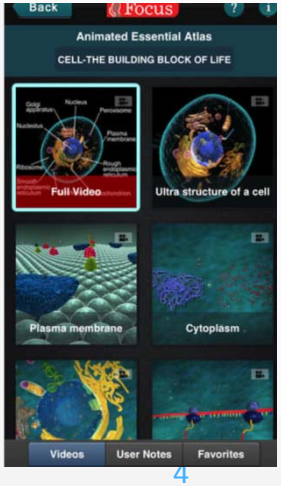
Content
- **Systems**
  - Skeletal
  - Muscle
  - Circulatory
  - Nervous
  - Respiratory
  - Digestive
  - Urinary
  - Reproductive
- Differents limbs
- Differents organs
- Dynamic of the limb / organ
- Pathology's references
- Fracture's references

Format
- **Models**
  - 2 dimensions
  - 3 dimensions
  - 4 dimensions
- **Medias**
  - Animated
  - Video
  - Interactive
- Anatomical charts
- Anatomical slices
- Index / Anatomical atlas

Language
- English
- French
- Others

Status
- Paying
- Free
- "Lite" version





Training session of N.Balosso

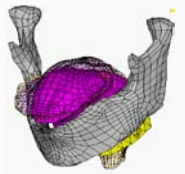
The proposed approach: the LBA

Capture (speech, motion)

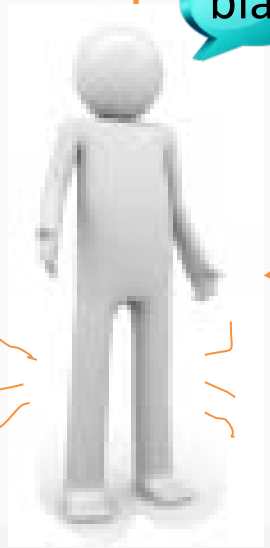
User-model mapping

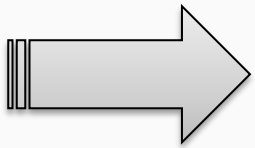
Interaction devices

Knowledge base
- Fonctional anatomy
-Biomechanics
-Images, clinical cases
Etc.

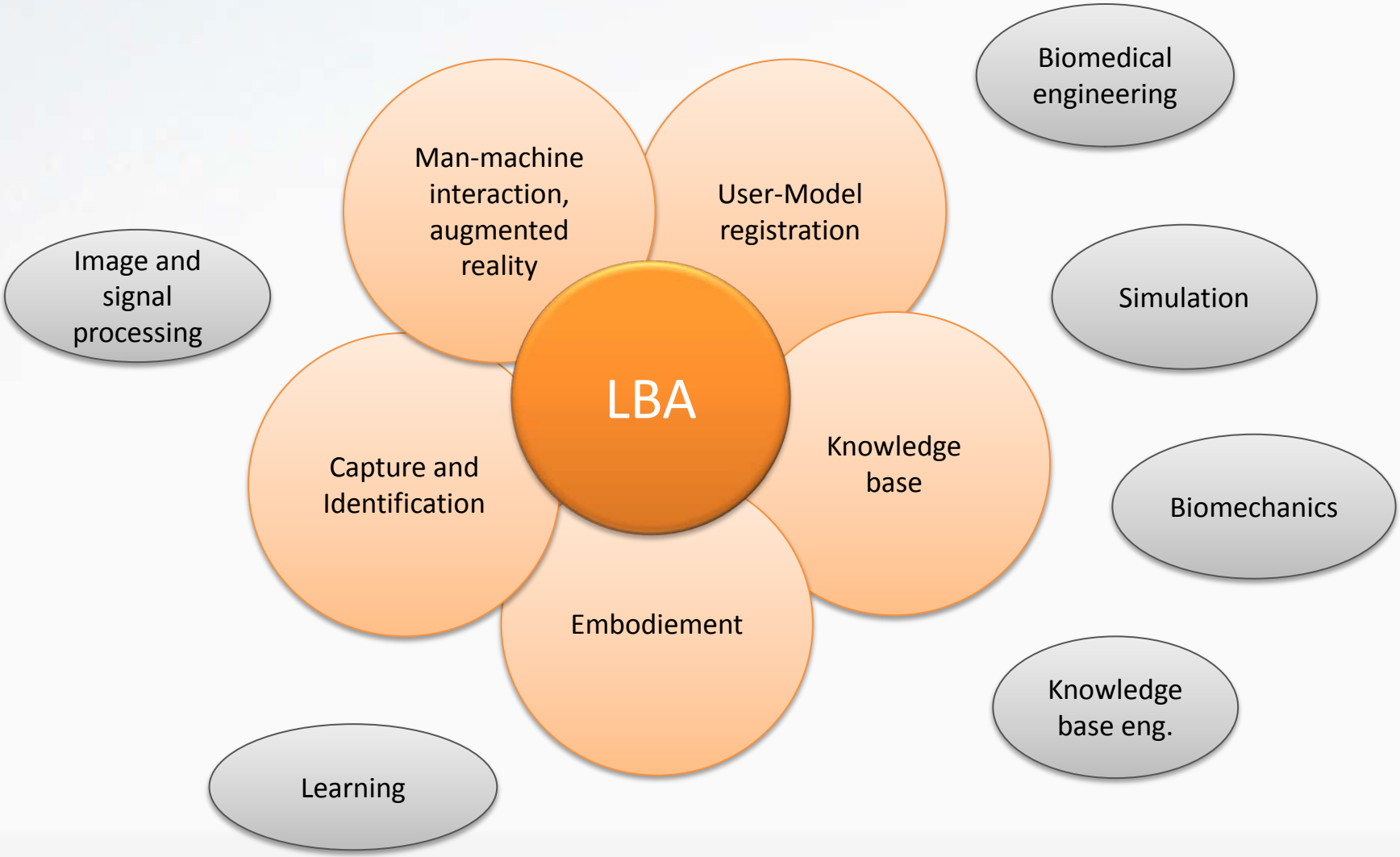


bla





Scientific program

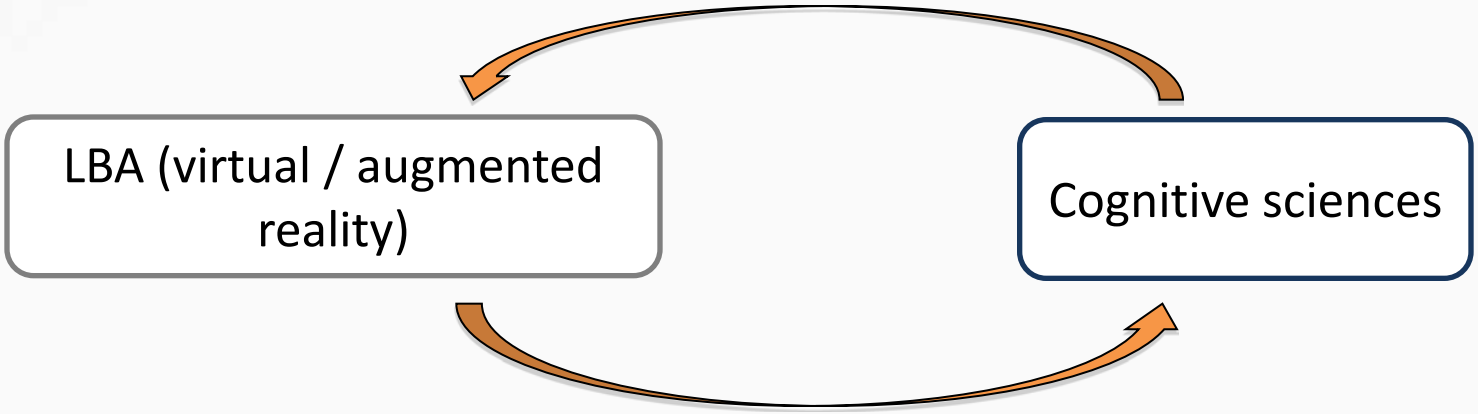


LBA and cognitive sciences

« Recent theories of human cognition suggest that the mind is not an isolated system but rather is integrated into the body's sensorimotor systems, and that our representations of objects and events are linked to our experiences of acting on the world. »

Cartmill, E. A., Beilock, S., & Goldin-Meadow, S. (2012). Phil Trans of the Roy Soc B: Biol Sc, p.130

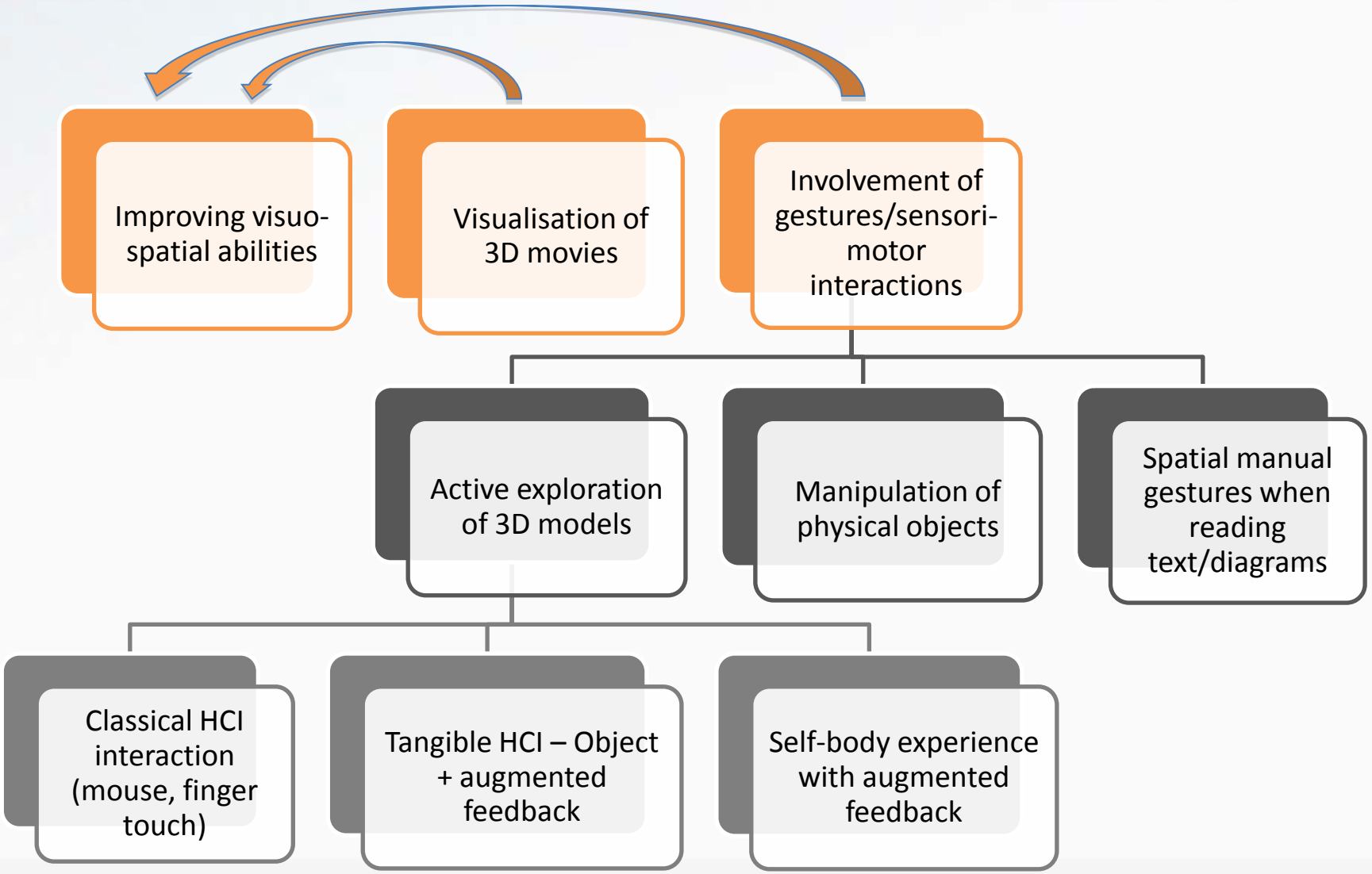
Provide methods and models to improve new technologies for learning



Provides new experiences of acting on the world to address the integration of cognition into sensori-motor experiences

LBA benefits from insights in cognitive sciences but is also a good framework to address fundamental issues in cognitives sciences

What could help anatomy learning ?



https://persyval-lab.org/en/sites/lba/content/lba-illustrative-references-cognitives-sciences-aspects

Evaluation of LBA

Balanced groups - skills that could influence learning

Pre-evaluation

- Visuo-spatial abilities
- Anatomy knowledge
- Practice of 3D software

Naive subjects (not familiar with anatomy), short term

Training phase

- Group 1 (n=10-15): Passive 3D movies
- Group 2 (n=10-15): Active exploration of 3D models
- **Group 3/4 : LBA**

Post-evaluation

- Multiple choice tests, terminology/comprehension
- Labelling of diagrams,…

Define visuo-spatial tests (e.g. work at CRIS, cf. N. Hoyek seminar) + questionnaries

Define lesson of structural and functional anatomy (knee, vocal tract). 3D interaction, classic HCI

Define evaluation tests. Interaction evaluation-learning?

Nicolas's internship

LBA, interaction between action/feedback, comparison between med-school, physiotherapists etc

Master 2R sciences co? 2014-2015 (Active vs. passive 3D learning)

Post-doc. 2015-2016

Knowledge base: the MyCF ontology

O;Palombi, MD, PhD

- Description of anatomic objects, constraints, functions and 3D aspects

« 3Dmodel1 describes the Sartorius which is a Muscle that participates to the Flexion of the Knee »

- Reasoning and declarative querying capabilities on knowledge

« Which 3D objects refer to muscles that participate to the Flexion of Knee ? »

- Evolutive and efficient tool for knowledge driven 3D anatomic models in realtime

Results

- MyCF Ontology version 2 published

  (Journal of Biomedical Semantics 2014)

  - New classes, properties, and inference rules previously not exploited
  - Link between the world of anatomy and that of 3D
  - Ontology deployed on a Sesame triplestore, accessible from https://mybody.inrialpes.fr/mycf/
- Browser 3D for visualization of human body models

  (Armelle Bauer thesis, Demo/Talk SIGGRAPH 2014)

  - Interactive browsing based on ontology querying
  - Web Browser accessible from mycfbrowser.inrialpes.fr/mycf/
- Experimentations for transferring MyCF on SmartDevice

  (Uzma Rifat Master Thesis)

  - Autonomous devices for learning session
  - Ontology storage, querying and 3D display experimented on Android

Perspectives

- Challenges in real-time ontology querying
  - Evaluate complex queries on RDF triplestores
  - Deal with SmartDevice memory and communication constraints

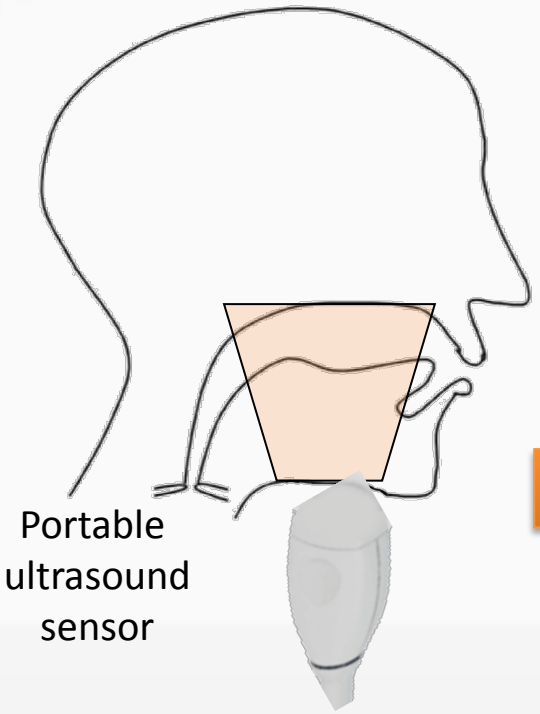
- Application to related fields: results directly relevant for LBA
  - Embryology: ontology driven 3D simulation of embryos development
    (P.-Y. Rabattu et al., work in progress)
    - Development of a new spatio/temporal ontology for describing embryos
    - Simulation and visualization are developed inside Blender software
  - My3D : software assistant for the composition of human models
    - Development of a domain ontology for mechanical simulation

LBA for understanding tongue biomechanics

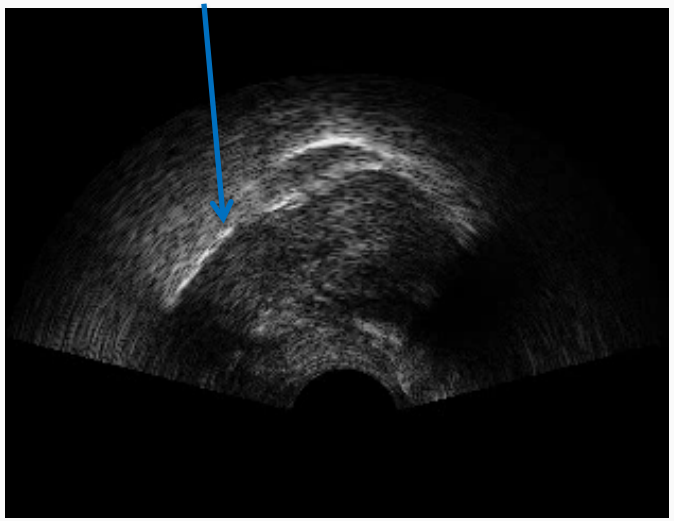
Goal: Helping medicine students to understand biomechanics of the tongue

Tongue: Complex organ (8 muscles) – Major role in human speech production

Tongue movements can be captured in a non-invasive manner using ultrasound imaging



Upper surface of the tongue



Lips

Glottis

→ not very intuitive (no muscular activation patterns)

Envisioned systems

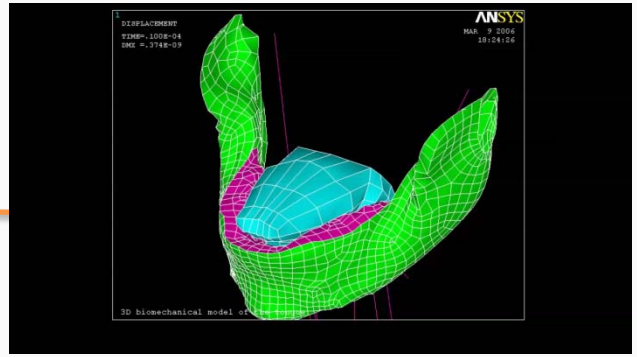
Short-term (audio-to-gesture)

Acoustic speech signal

Automatic speech recognition (phonetic level)

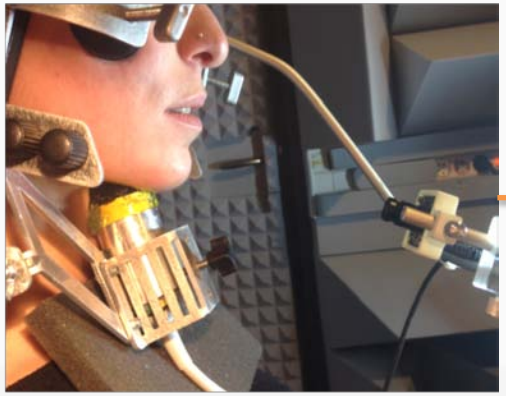
/a/, /i/, …

3D rendering



Pre-computed animation

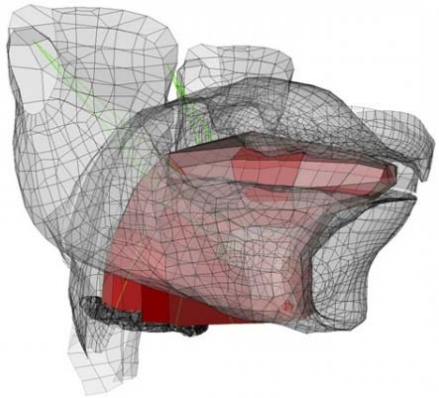
Tongue movements captured using ultrasound



Mid/long-term (ultrasound-to-gesture)

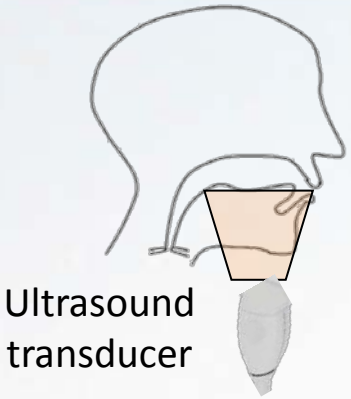
Gesture recognition

3D rendering

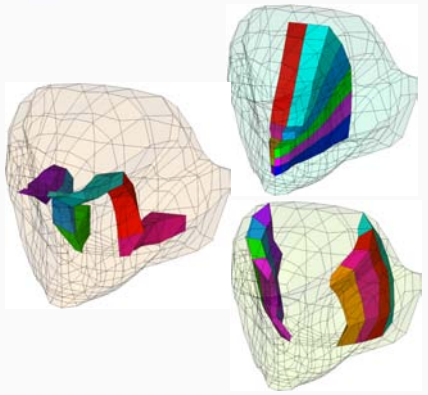


Pre-computed animation re-shaped to fit user articulation/geometry

Ultrasound to gesture



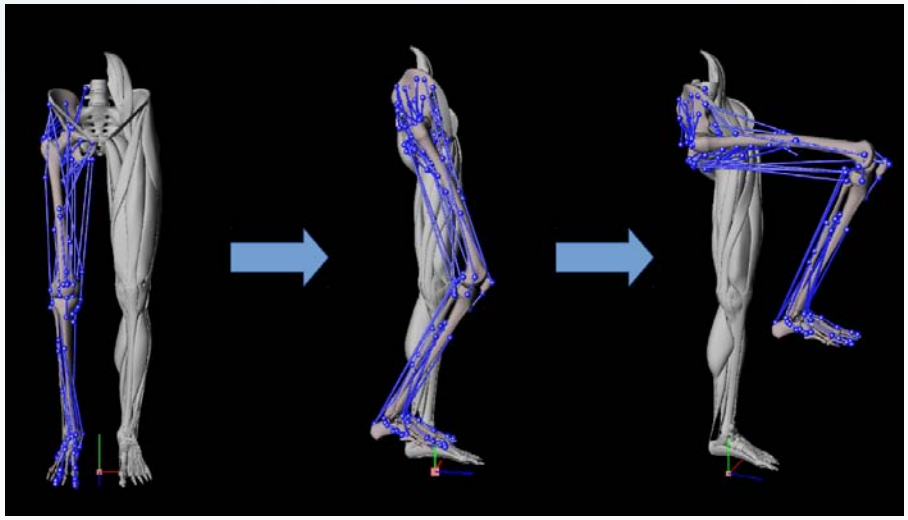
Gesture recognition → 3D rendering →



6 month post-doctoral position open

- Gesture recognition : extracting sequences of elementary tongue gestures in ultrasound images (such as phonetic or sub-phonetic gestures).
  - Robust visual feature extraction (image processing)
  - These techniques could be based on Hidden-Markov Model (or more complex graphical models), Conditional Random Fields, or Time-delay Neural Network.
  - Real-time processing
- Trigger animation of pre-calculated 3D biomechanical model developed by Buchaillard et al.

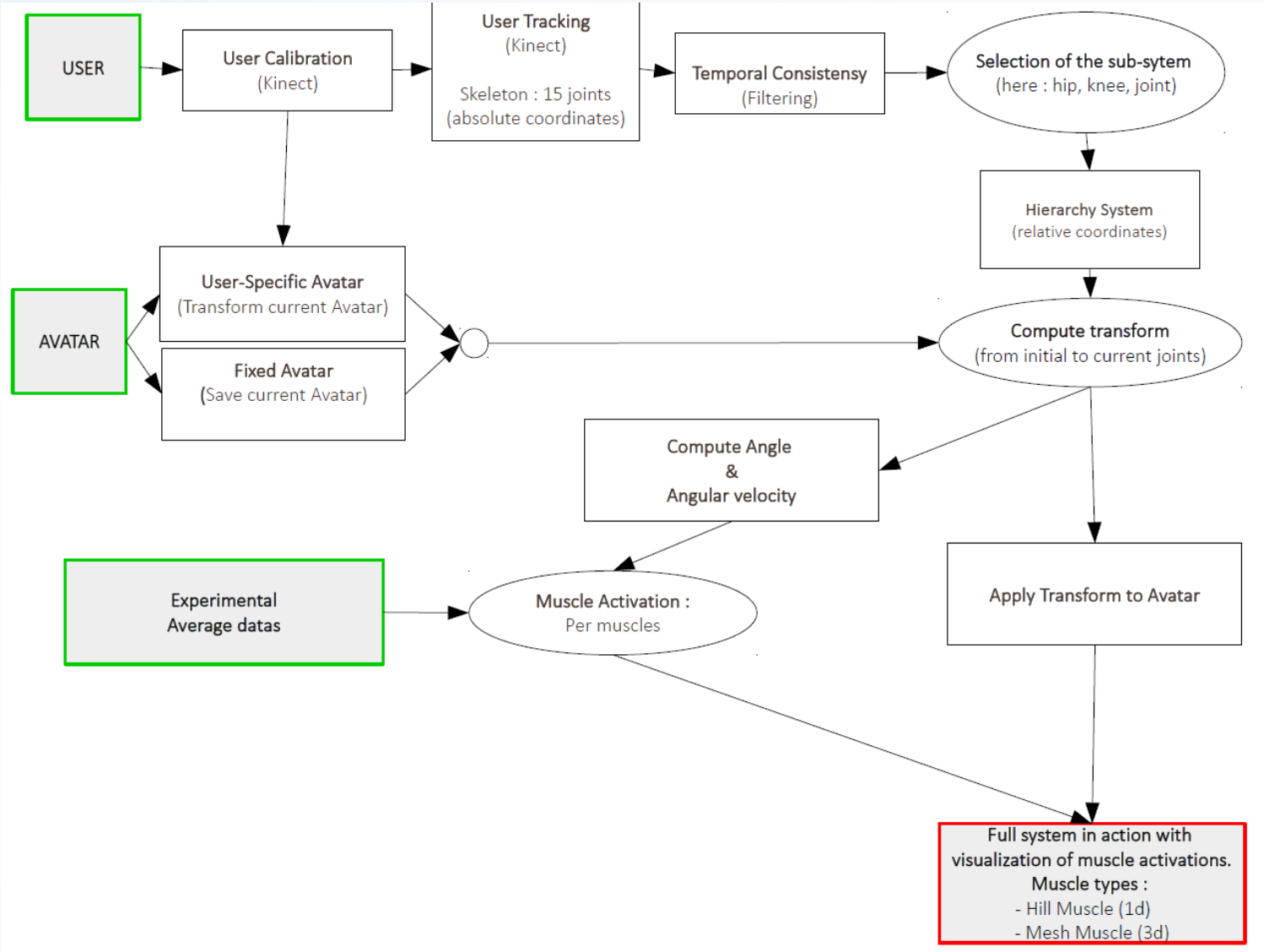
LBA for understanding leg biomechanics



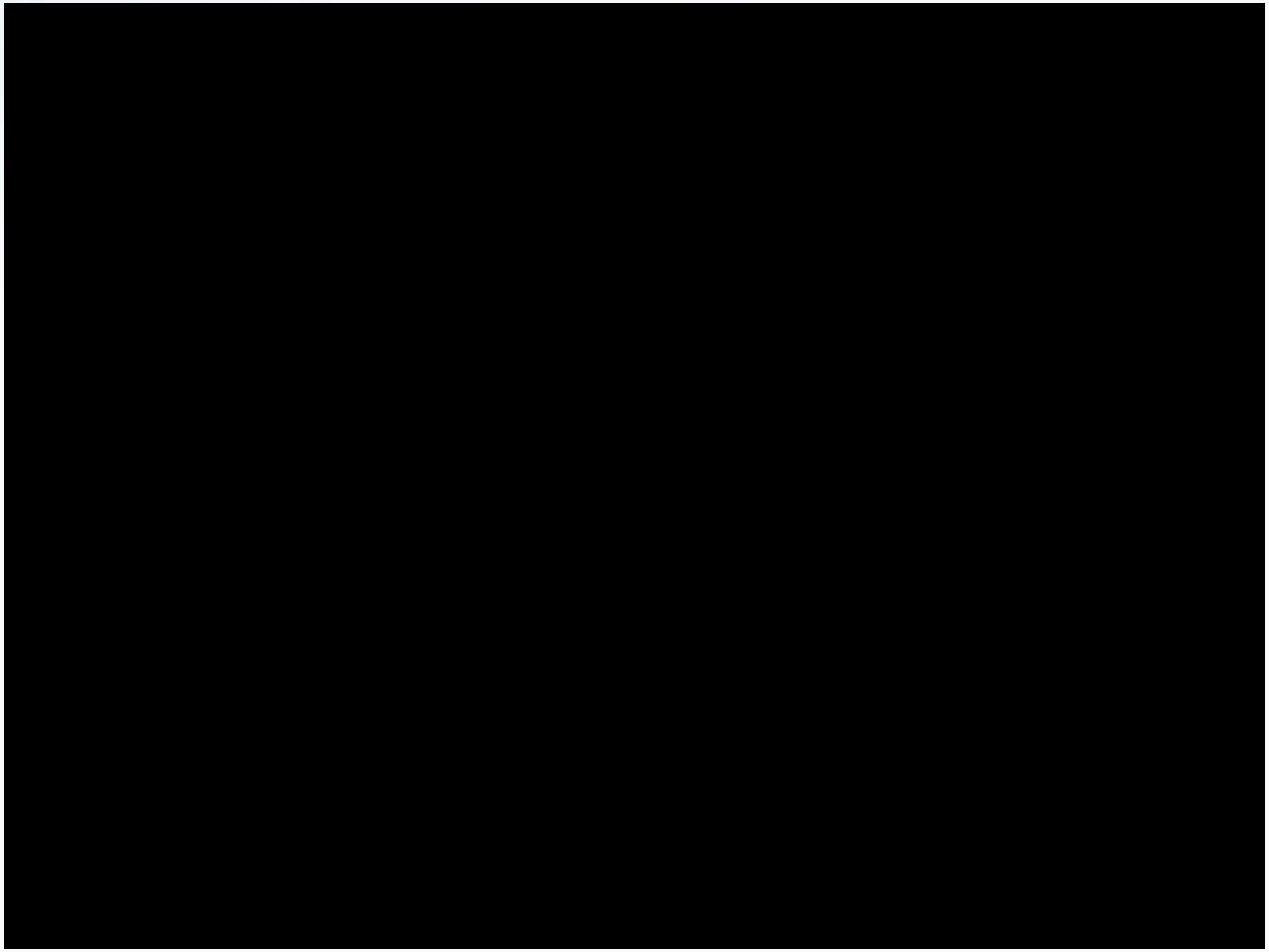
PhD work of
Armelle Bauer

- Capture real motion
- Deform the avatar to the user
- Animate the user-specific avatar
- Identify and visualize corresponding muscle activation

The implemented « demo »



The very first demo



Motion capture and identification

Experimental measurements

(lower limb flexion-extension)

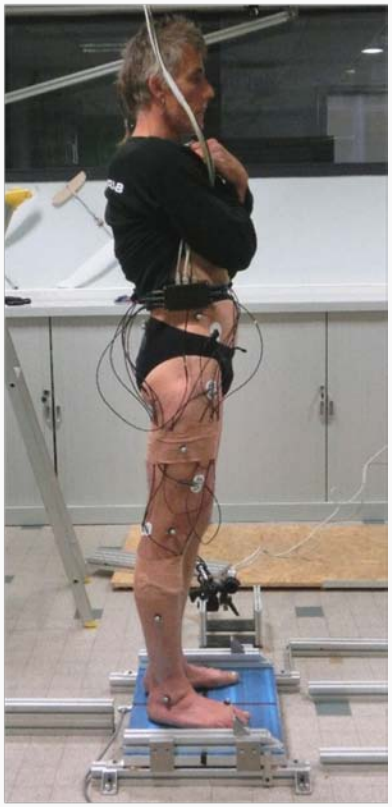
+

Biomechanical modeling

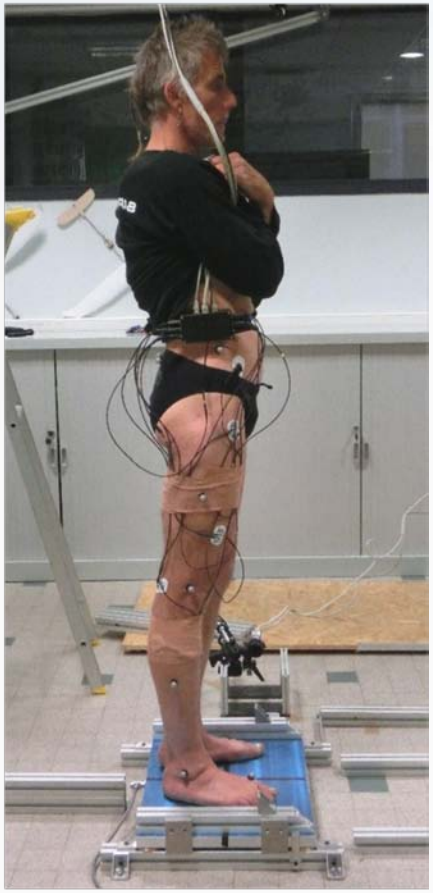
Knee muscle activation prediction with agonist and antagonist co-contraction

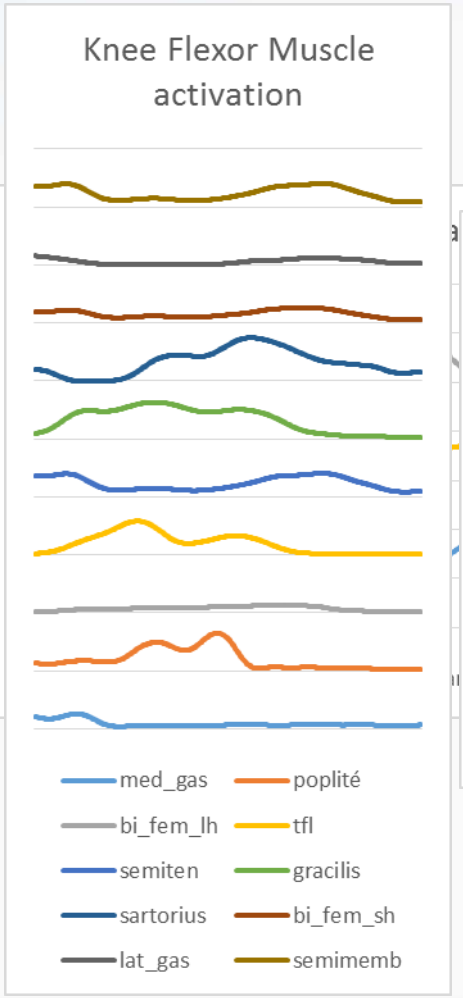
Experimental measurements

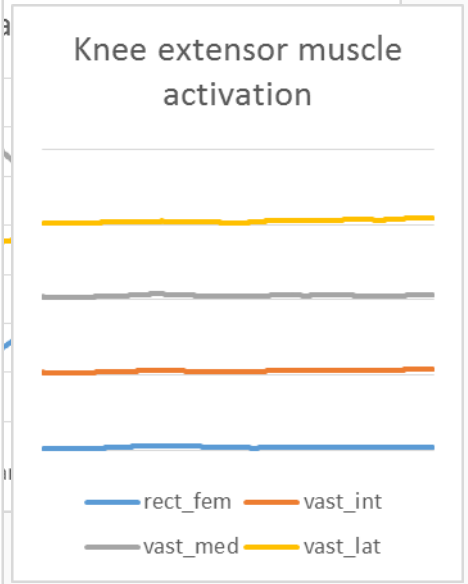
- Acquisitions on the MOCA platform
  - Kinematic data (Vicon)
  - Ground reaction forces
  - Muscular activation (EMG)



Processing stages

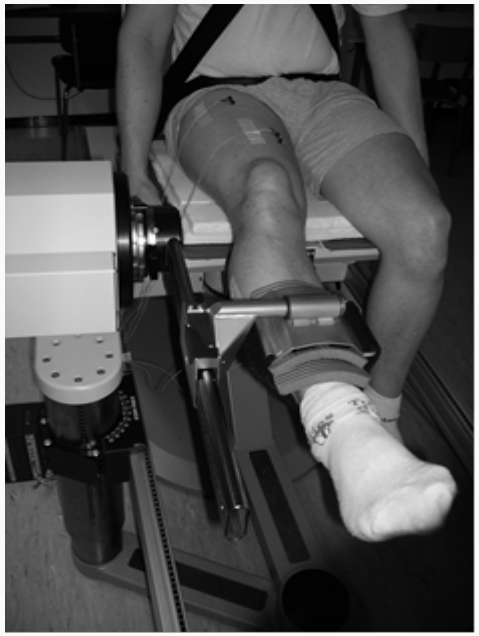






Motion capture and identification : perspectives

- Additional measures of muscle activation in maximal voluntary contractions (isokinetic ergometer)
- Different kind of flexion-extension movements (velocities, forces…)
- Various subjects
- Development of a biomechanical lower limb model to estimate muscle force production



User mapping : perspectives

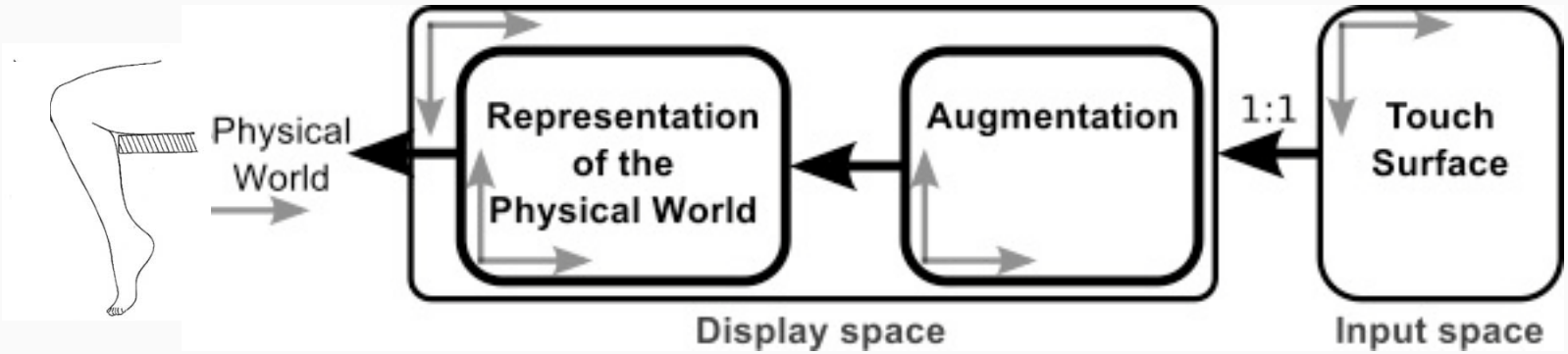
- From kinematic mapping to more complex one
- Local mapping with limited views of the trainee
- Accuracy (space, time) issue [for AR]
- Evaluation (ground truth capture from Kinovis?)

Augmented Reality

- Augmented Reality merges digital information in the physical world
- LBA use case: Overlaying a dynamic anatomical model on the student's body
  - Benefit: Colocation body/model
  - Question: Does it help learning of anatomy?
  - Limitation: Colocation limits interactions, for example the default viewpoint is bound to the viewpoint of the user or of the device.

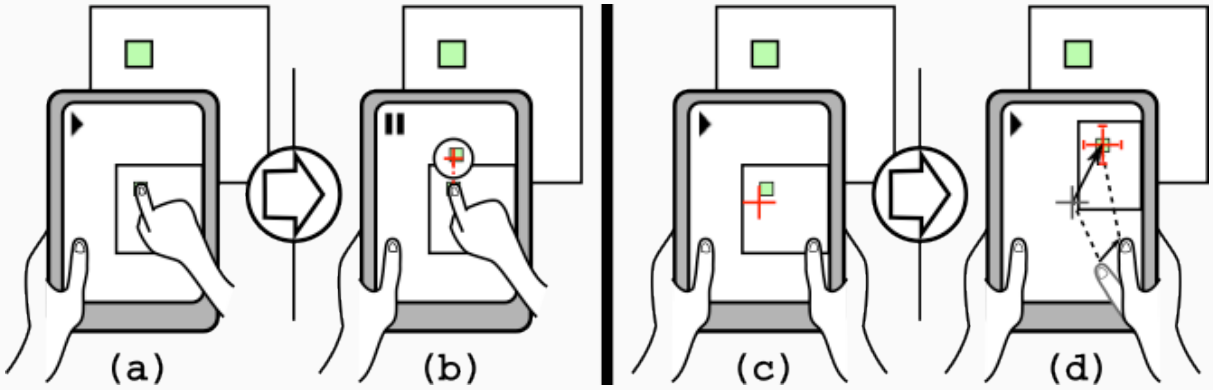
AR: first contributions (1)

- Design space: Defining key entities to consider for interaction with Augmented Reality applications on handheld devices (smartphones, tablets)



AR: first contributions (2)

- Accurate pointing technique allowing to select a point in the physical surrounding or on a digital augmentation.
  - To access information
  - To author annotations



AR: perspectives

- Development of an Augmented Reality application on handheld devices displaying LBA information .
- Exploration of viewpoint changes (e.g. turning around the knee) to relax the constraints on the default viewpoint.
- Study of the effect of Augmented Reality on the learning of anatomy.

12 month post-doctoral position

Main people involved

- TIMC/ GMCAO team (Bauer, Chabanas, Payan, Promayon, Troccaz)
- LJK/INRIA IMAGINE team (Bauer, Dicko, Faure, Palombi)
- Gipsa-lab:
  - SAIGA team (Cahouet, Paclet)
  - MAGIC team (Perrier, Hueber, Rochet-Capellan)
- LIG:
  - IIHM team (Nigay, Pelurson, Vincent)
  - HADAS team (Jouanot, Ulliana)

In collaboration with: LADAF, Medicine School, Kinovis platform, LSE