

Haptic Training Simulators Design Approach

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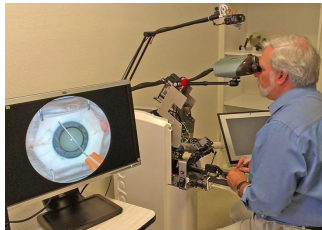
Context of medical training

- Learning from the patient poses ethical problems due to the associated risks
- So, currently, medical training emphasizes observation over hands-on practice
- However, mastering the dexterity of surgical instruments demands practice!

**How learning medical gestures efficiency
without any risk for the patient?**

One solution is to propose new training simulators based on Virtual Reality, combining:

- **Numerical simulation** replicating organ behavior during their interactions with each other and medical instruments
- **Haptic device** simulating sensations experienced during the procedure
- **Didactic software** providing tailored learning scenarios
(including scoring, progression, evaluation)



HelpMeSee - cataract



HRV - dental

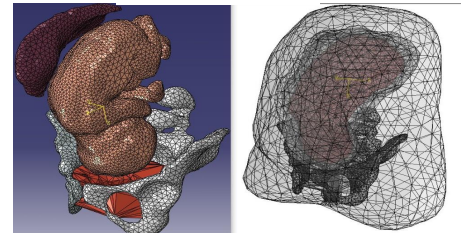
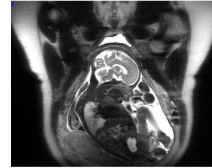


Lap Mentor - laparoscopy

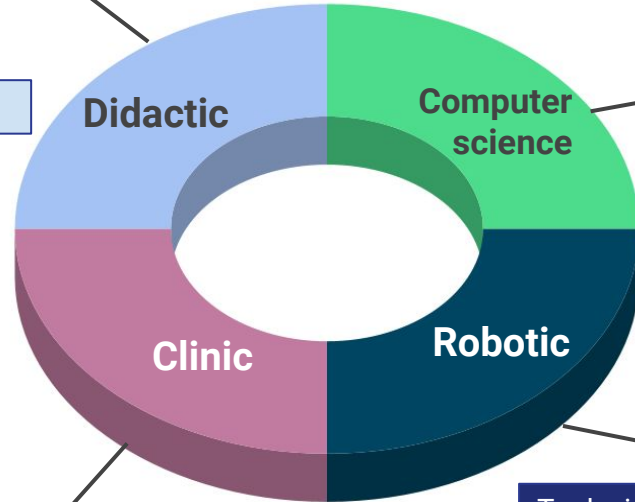
Approach comparable to that of simulation for air pilots

A necessary multidisciplinary approach

To develop a real-time numerical simulation replicating the behavior of organs during the gesture



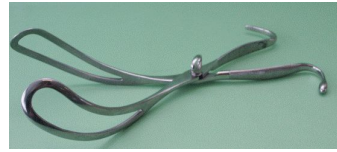
To design a haptic device that accurately reproduces the sensations experienced during the gesture



1- To analyze and understand the gesture and its learning to identify the pertinent components of the simulator

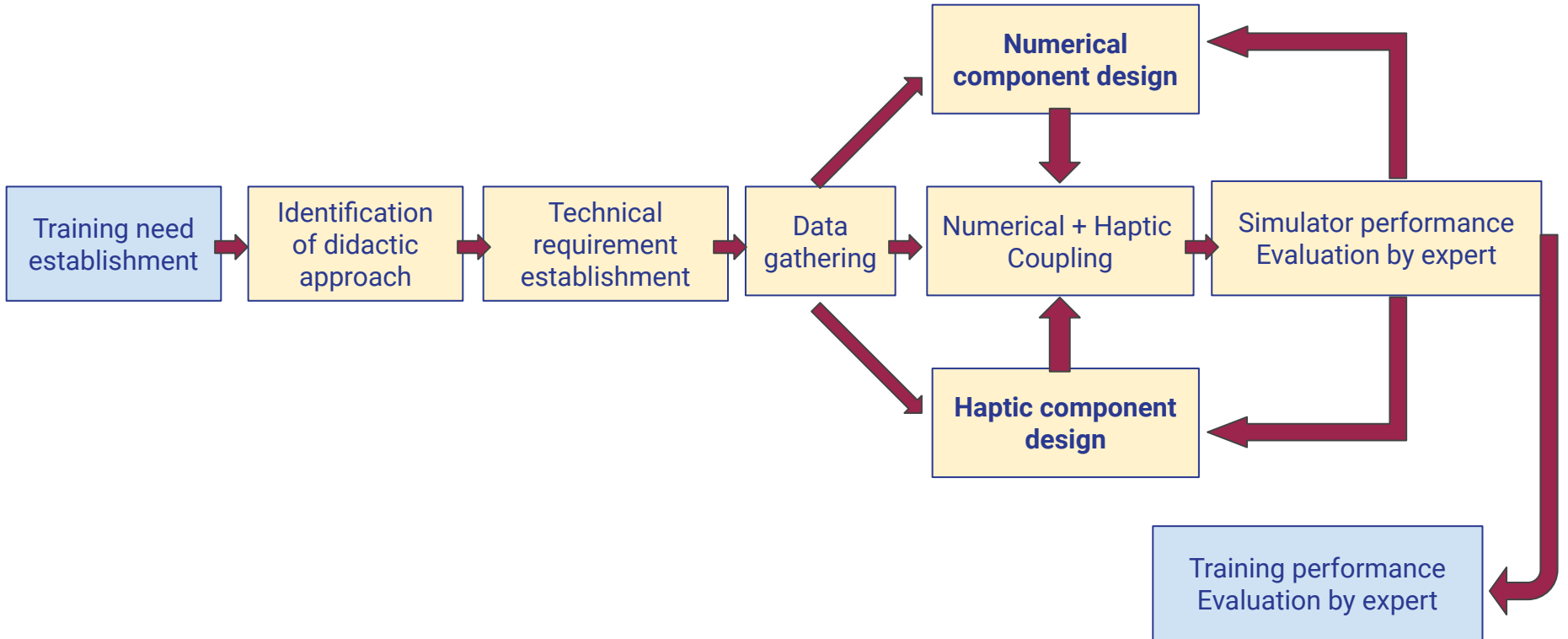
2- To develop pertinent and progressively advancing scenarios for learning

3- To assess the simulator's impact on learning



To validate the different components of the simulator

Haptic Training Simulator - Design Process



Haptic Training Simulator - Architecture

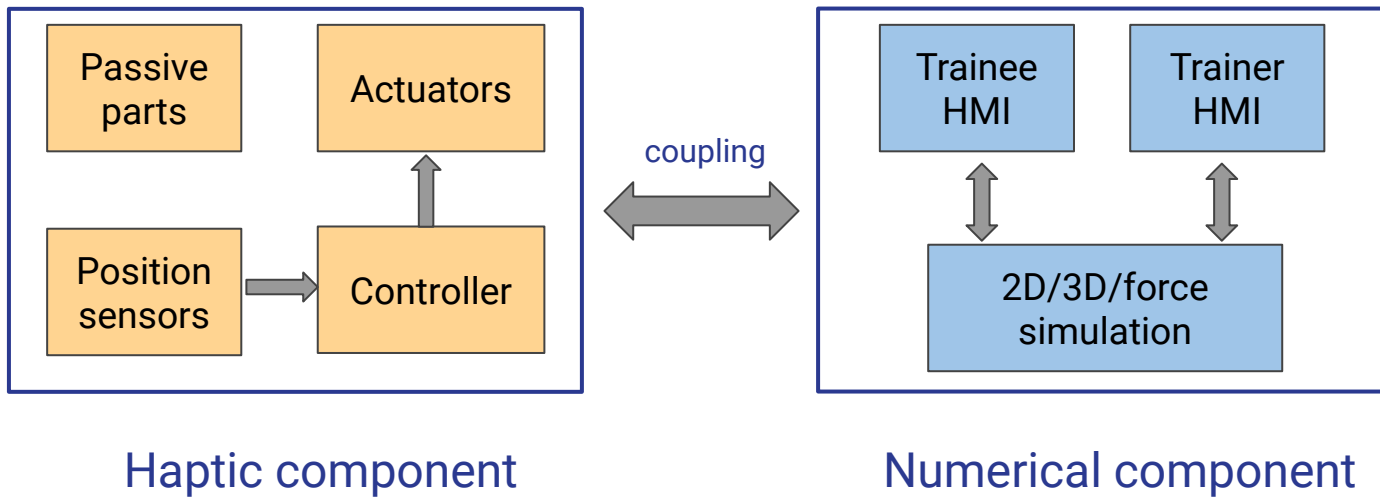
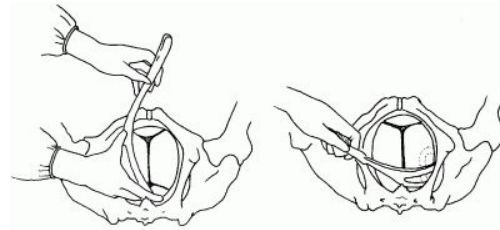
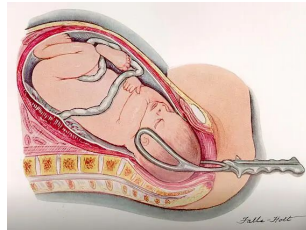


Illustration of HTS

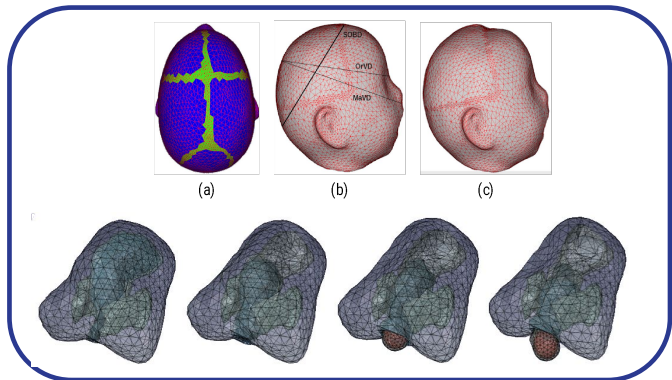
Context of medical training at gestures of childbirth

Medical objectives

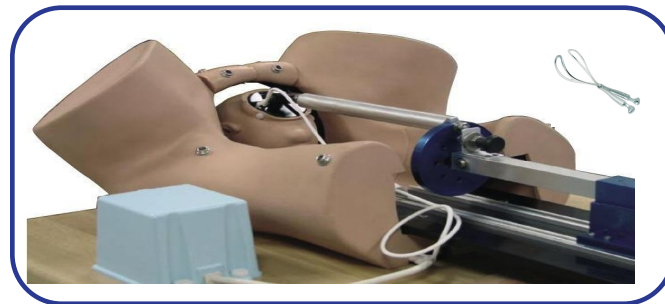
- **Acquire the right gestures for forceps extraction during childbirth**
 - Understand the intended gesture
 - Prevent any harm to the tissues of the parturient and the fetus
- **Be prepared to do this, to reduce the necessity for cesarean sections**
- **Operate effectively in delicate contexts**
 - Where the parturient is conscious, where the husband is present



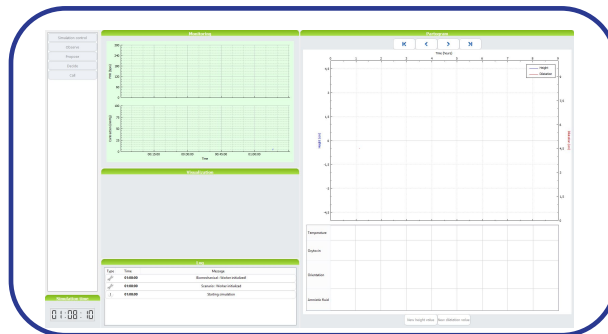
Results - A childbirth simulator based on VR



LIRIS, lab. TIMC-IMAG, CAOR ARMINES
3D simulation in real-time



Lab. Ampère, CAOR ARMINES
Custom haptic device

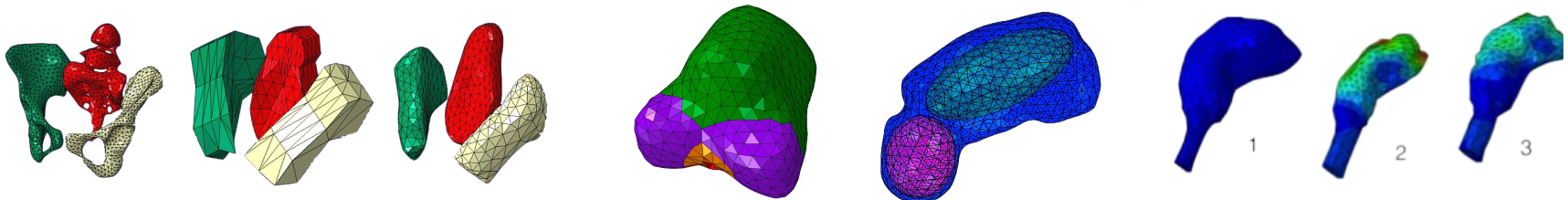


All4Tech, HRV, LSE, Lyon Sud maternity, midwifery school of Grenoble (France)
Didactic software

- **Simulating and visualizing the behavior of organs in real-time**
 - Validation through clinical acknowledgements and comparison with accurate simulations
- Proposing an **adequate haptic device** rendering kinesthetic sensations
 - Feelings tested by obstetricians
- Ensuring the **stability of the complete solution**
 - Loop between Numerical model, Haptic interface, and Trainee

Challenges for the numerical simulation

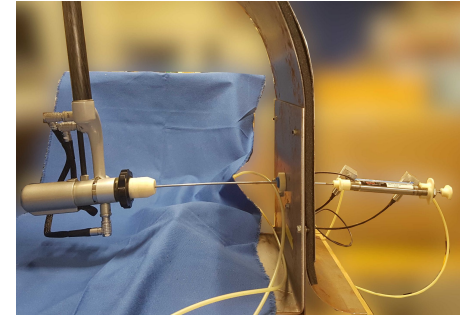
- **Simplifying the models** (geometric / biomechanical / boundary conditions) while maintaining **sufficient realism for training purposes**
- Evaluating errors related to the approximation of the numerical model (comparing with reality is challenging)
- **Being fast (and stable...)** for interaction with the haptic device



To find the adequate compromise between accuracy / execution time / stability

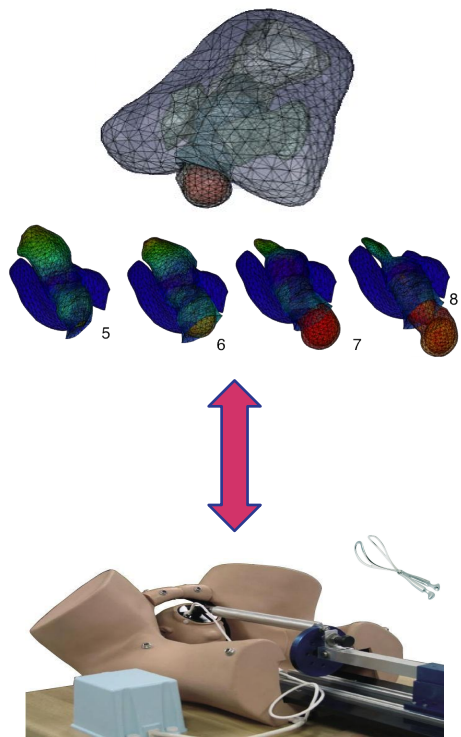
Challenges for the haptic component

- Replicating usual medical tools for **easier immersion** and **reusability** of acquired skills
- Rendering **realistic forces** and **variable stiffness**
 - with small magnitudes (insertion of a catheter in a ventricle, for instance)
 - with hard contacts (collision with bones)
- Using and mixing **adequate actuators** (Electric/Pneumatic/Rheological...)
- **Managing the coupling with the Numerical Simulation**
 - with different sampling periods (and without vibrations)
 - with fast, stable and robust control laws

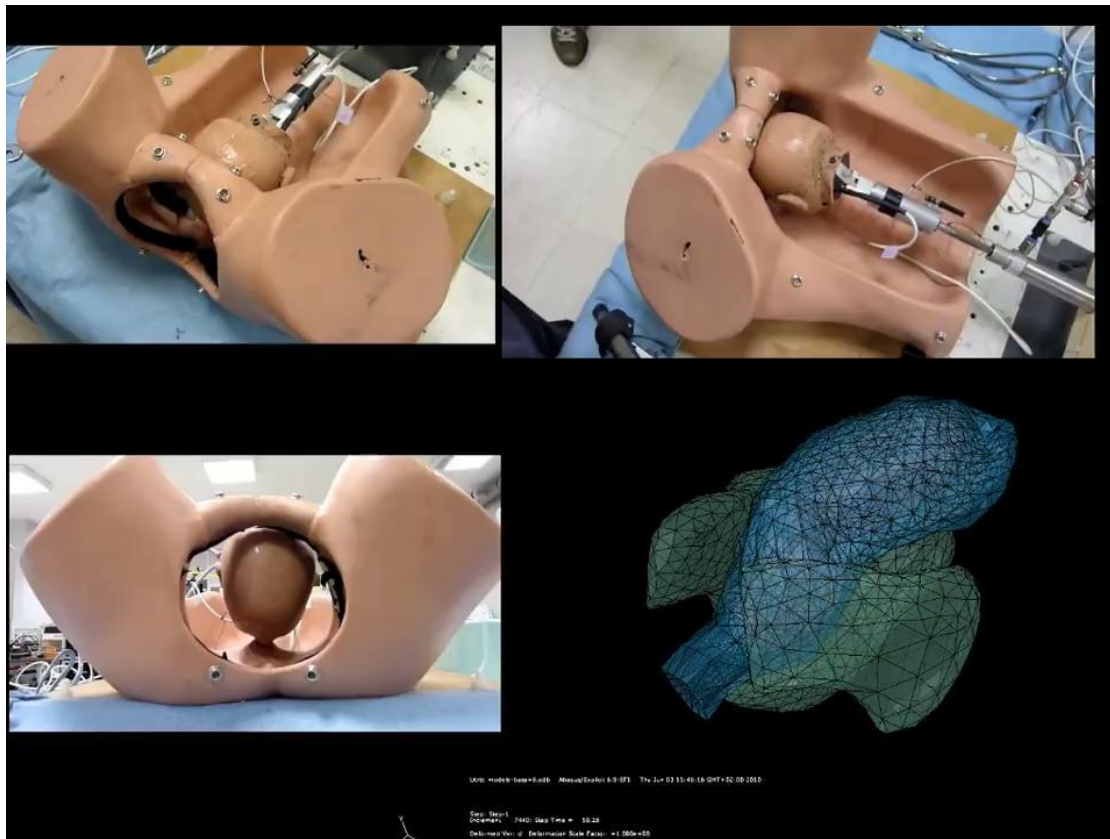


The complete childbirth simulator with a coupling between numerical and haptic components

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[Buttin 2013]



[SAGA project (ANR-12-MONU-0006)]

- The difficulty lies in ensuring that users do not merely learn to operate the simulator
- Rather, the simulator must facilitate **learning & training the authentic procedure**
- It is imperative that the simulator aids in:
 - Appropriating the correct gesture
 - Analyzing encountered situations
 - Acquiring the necessary dexterity for the procedure

"We have to learn how to operate a real patient and not to operate the simulator."

To conclude on Haptic Training Simulators interests

- **Expected interests of such simulators**
 - Acceleration of the learning process
 - Improvement of physiological knowledge
 - Implementation of new methods of gesture evaluation
 - Setting up new gestures

- **In the near future, for medical simulators: "specific patient"**
 - Training before risky operations
 - Pre-operative diagnosis / prediction to assess risks
 - Help during the intervention

To conclude on HTS design & development

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A long development process... to obtain a simulator that improves training of gestures

First validation :

- Simulation & haptics

Second validation :

- Integration of relevant learning scenarios
- The simulator must be able to reproduce these scenarios
- Management of common & rare situations: morphology, pathology, gesture to be performed

Third validation :

- Test campaign with practitioners
- Evaluation of the simulator's contribution for learning & training

... but it's worth the effort

Thank you for your attention

Speaker



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Any questions?



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