POLITECNICO DI MILANO
Bioengineering Department
NeuroEngineering and medicAl Robotics Lab
POLITECNICO MILANO

A-mode ultrasound acquisition system for computer assisted orthopaedic surgery

…and other

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Politecnico di Milano – Milan, Italy

Neuro**e**ngineering and medic**a**l **r**obotics **lab**oratory

www.biomed.polimi.it/nearlab

2 main projects

BONUS system

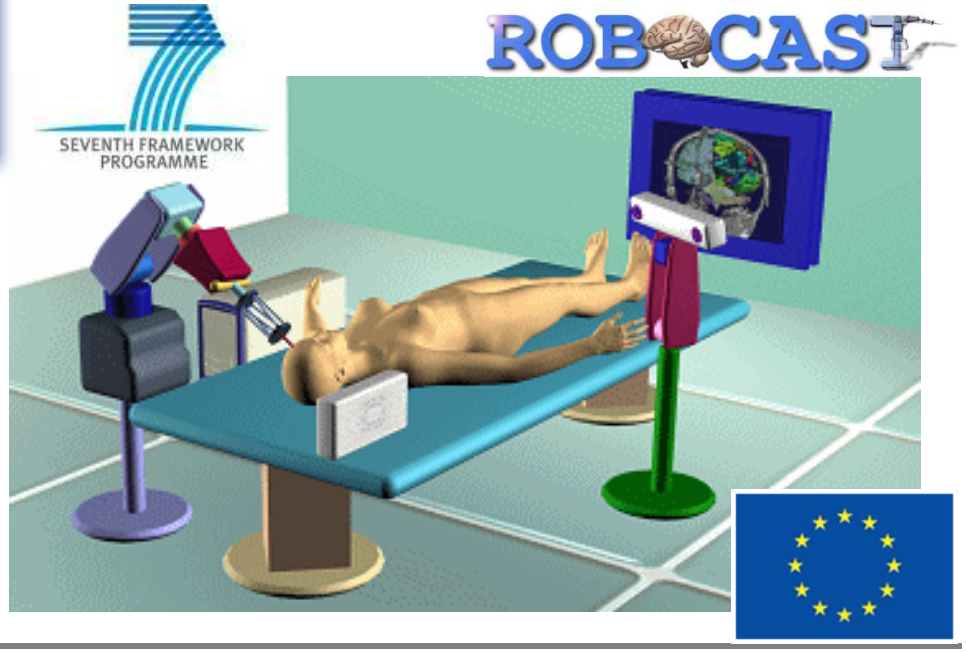
Computer assisted orthopaedic surgery

ROBOCAST

Keyhole neurosurgery

ROBOt and sensors integration for Computer Assisted Surgery and Therapy

www.robocast.eu



ROBOCAST Project

The Concept

KEYHOLE NEUROSURGERY

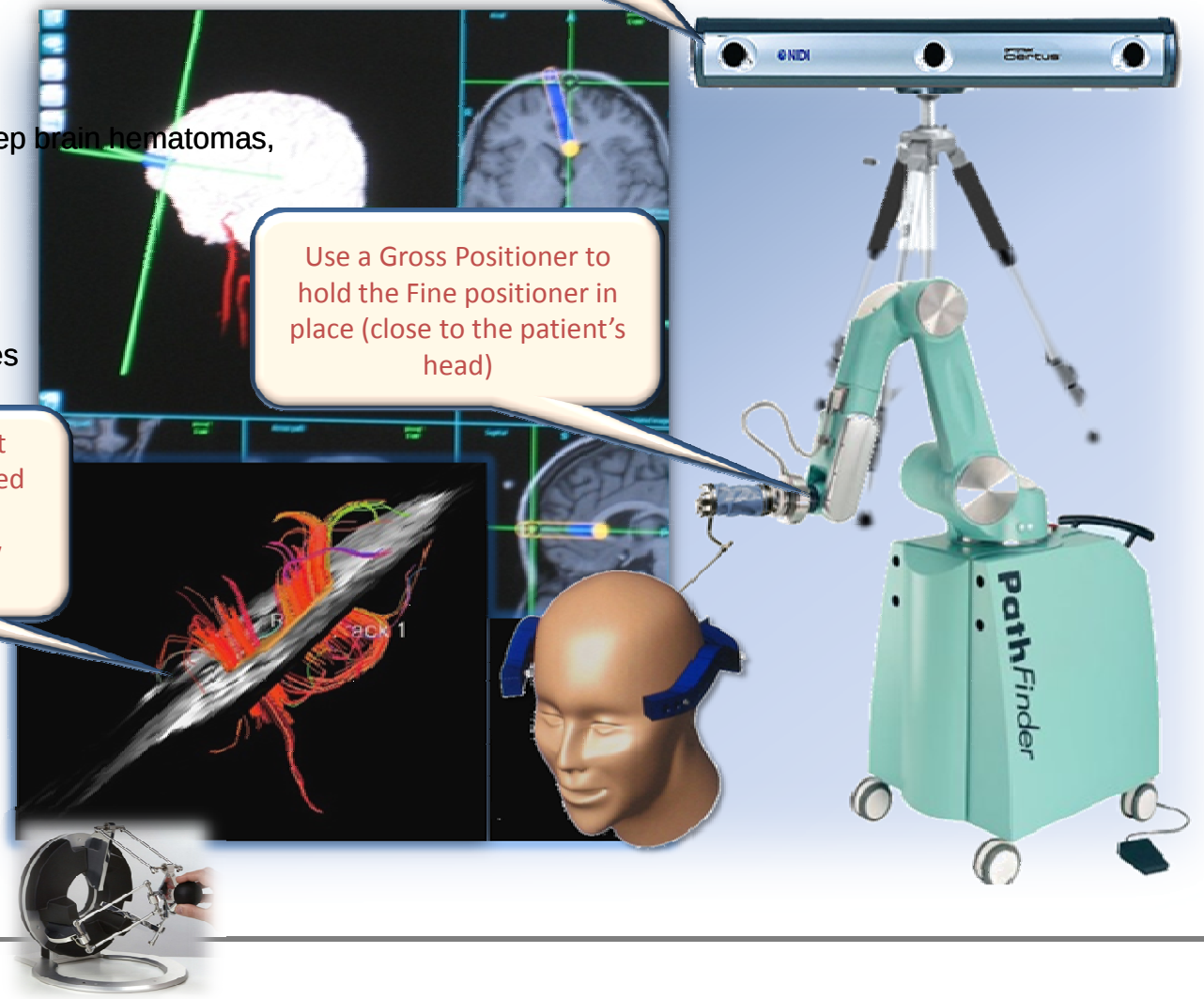
- ✓tumour biopsies,
- ✓treatment of hydrocephalus,
- ✓aspiration and evacuation of deep brain hematomas,
- ✓'Ommaya' catheter insertion,
- ✓deep brain stimulation,
- ✓and minimal access craniotomies

Closed loop control with external sensors (optical electromagnetic)

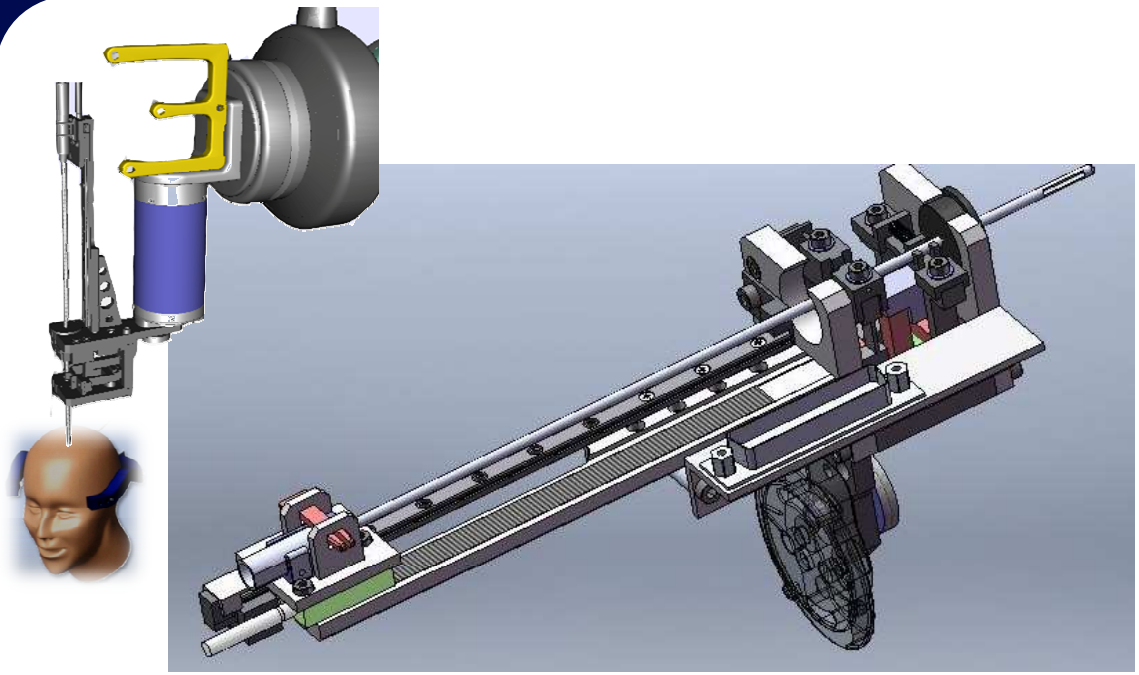
Use a Gross Positioner to hold the Fine positioner in place (close to the patient's head)

Develop an intelligent automatic planner based on risks atlas and updateable with new information

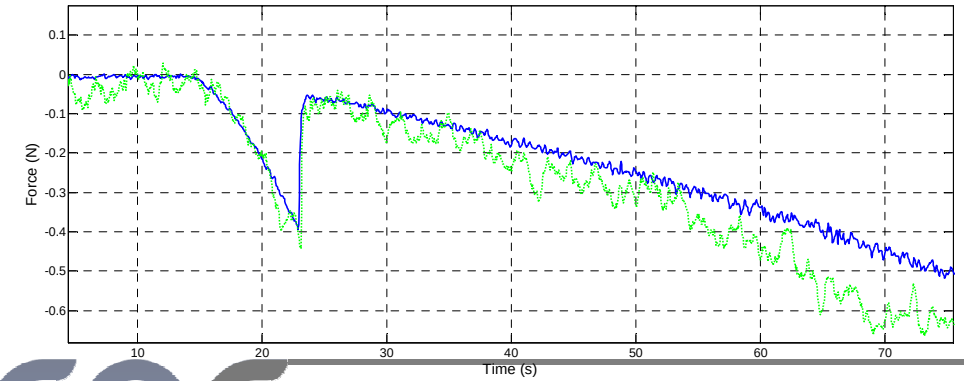
Surgeon is handling an haptic interface in order to perform the needle insertion

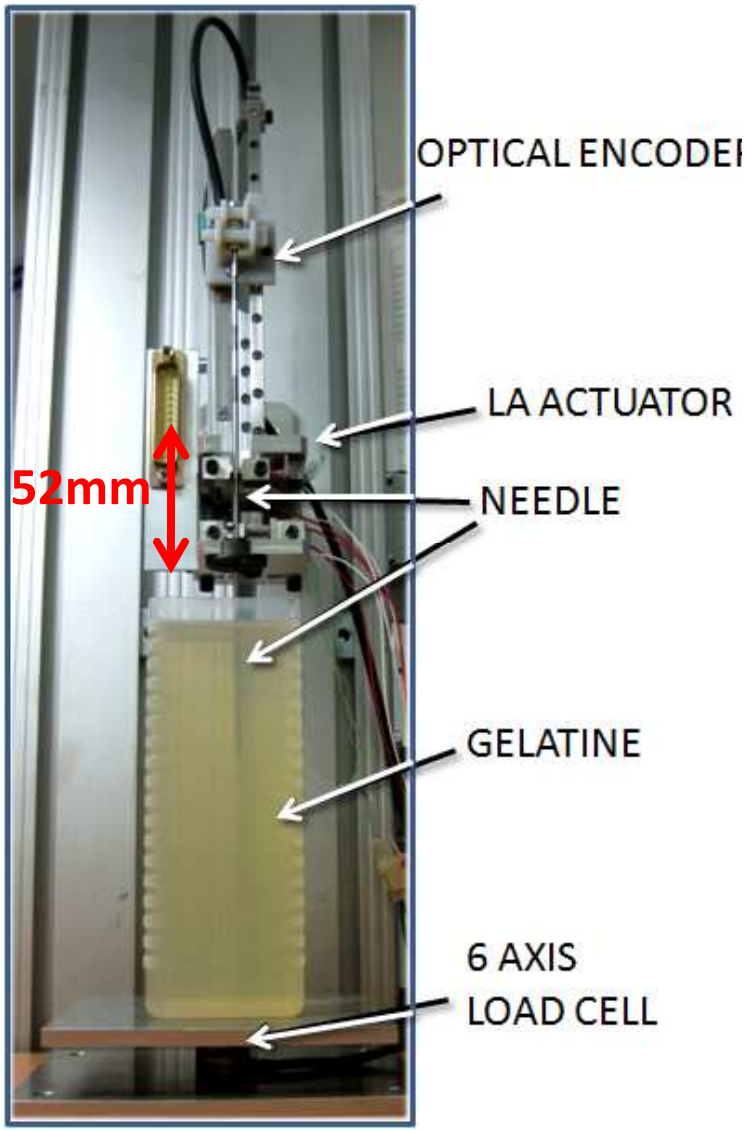


Force sensing



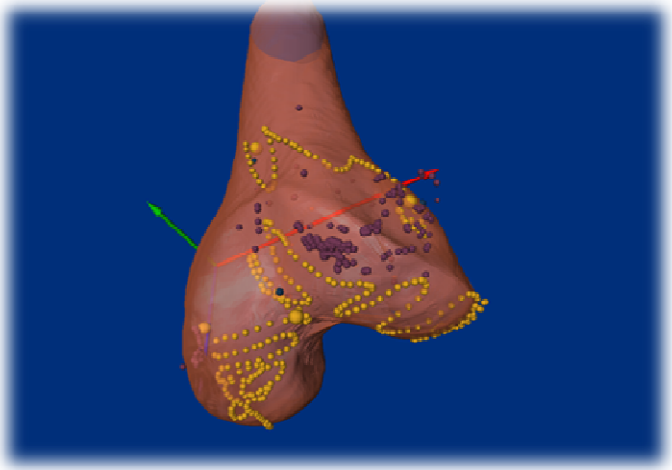
Credit: Ilya Dyagilev, MRL laboratory,
Technion University, Haifa (Israel)





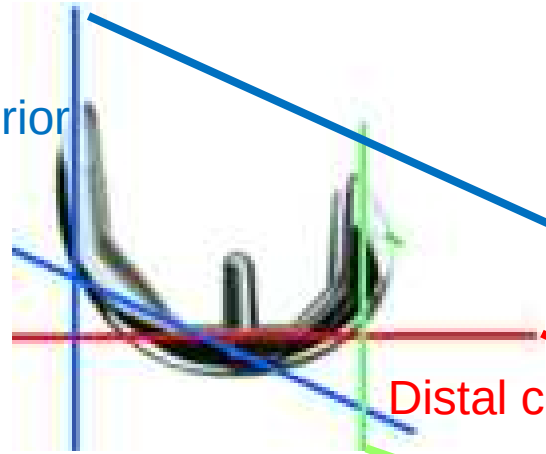
Aim

- **Validation of an ultrasound system for bone surface acquisition….**



- **… in computer assisted orthopaedic sugery.**

Knee prosthesis

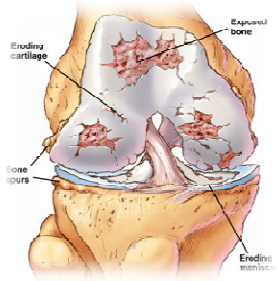


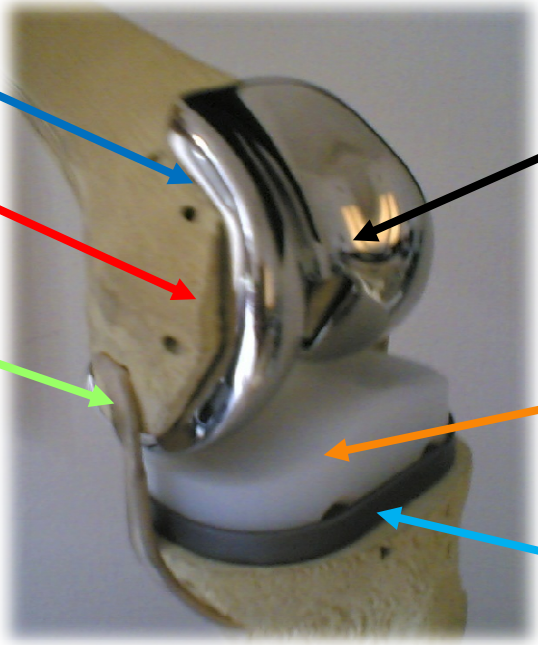
Anterior cut

Distal cut

Posterior cut

arthrosis
70% aged (>65 years) population affected





Thanks to Lima L.to, Udine Italy

Femural component

Liner

Tibial component

- **Requirements on cuts:**
  - Ex. The plane of the distal cut has to be perpendicular to mecha cal axe of the femur

Computer assisted orthopaedic surgery

Surgical navigation system

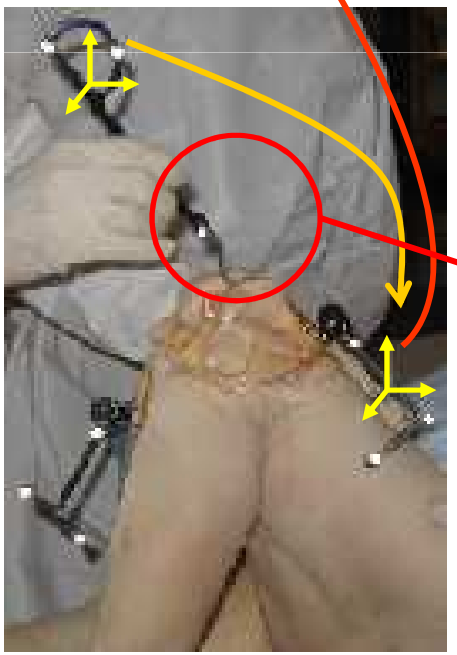
Optical localization system

Vicra NDI, Canada

Reference frames

Visual feedback

Registration

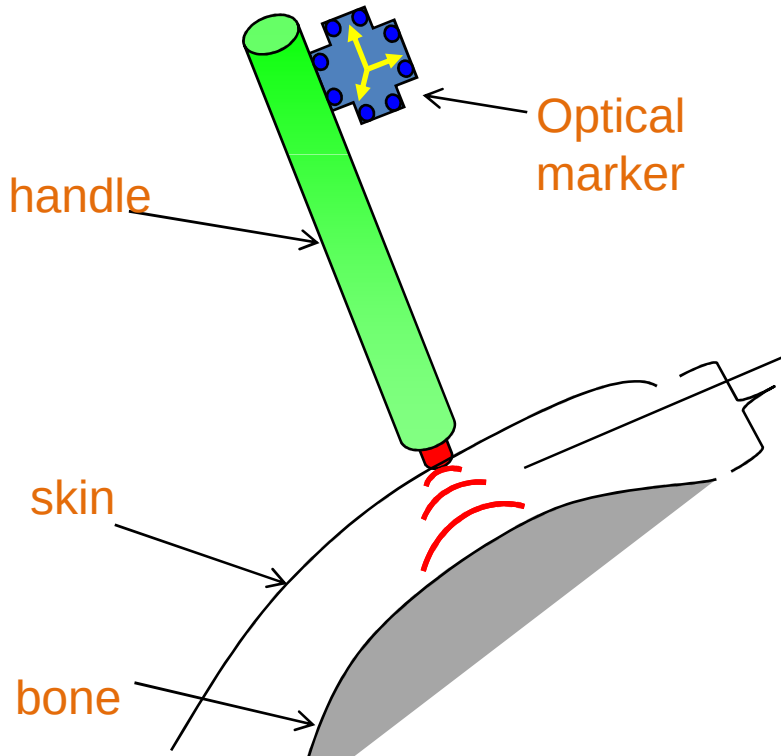


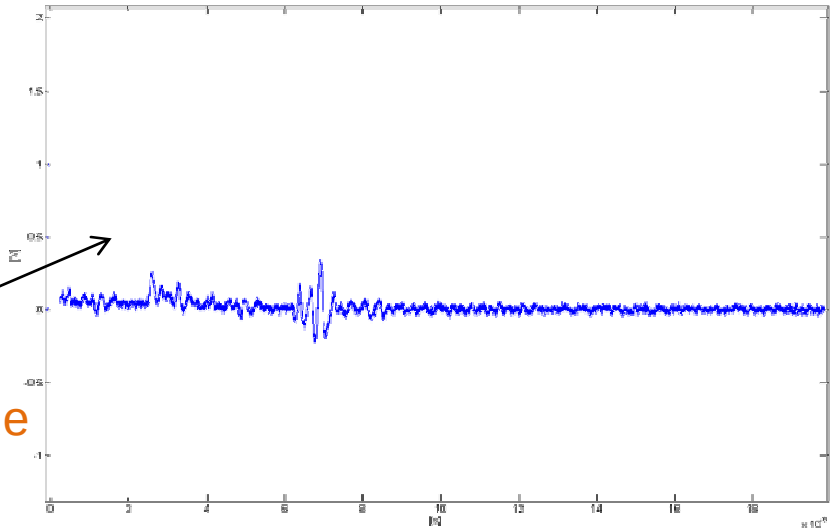
Localization error up to 7mm (Yau et al. 2005)

Affecting correct prosthesis insertion

Why ultrasound system?

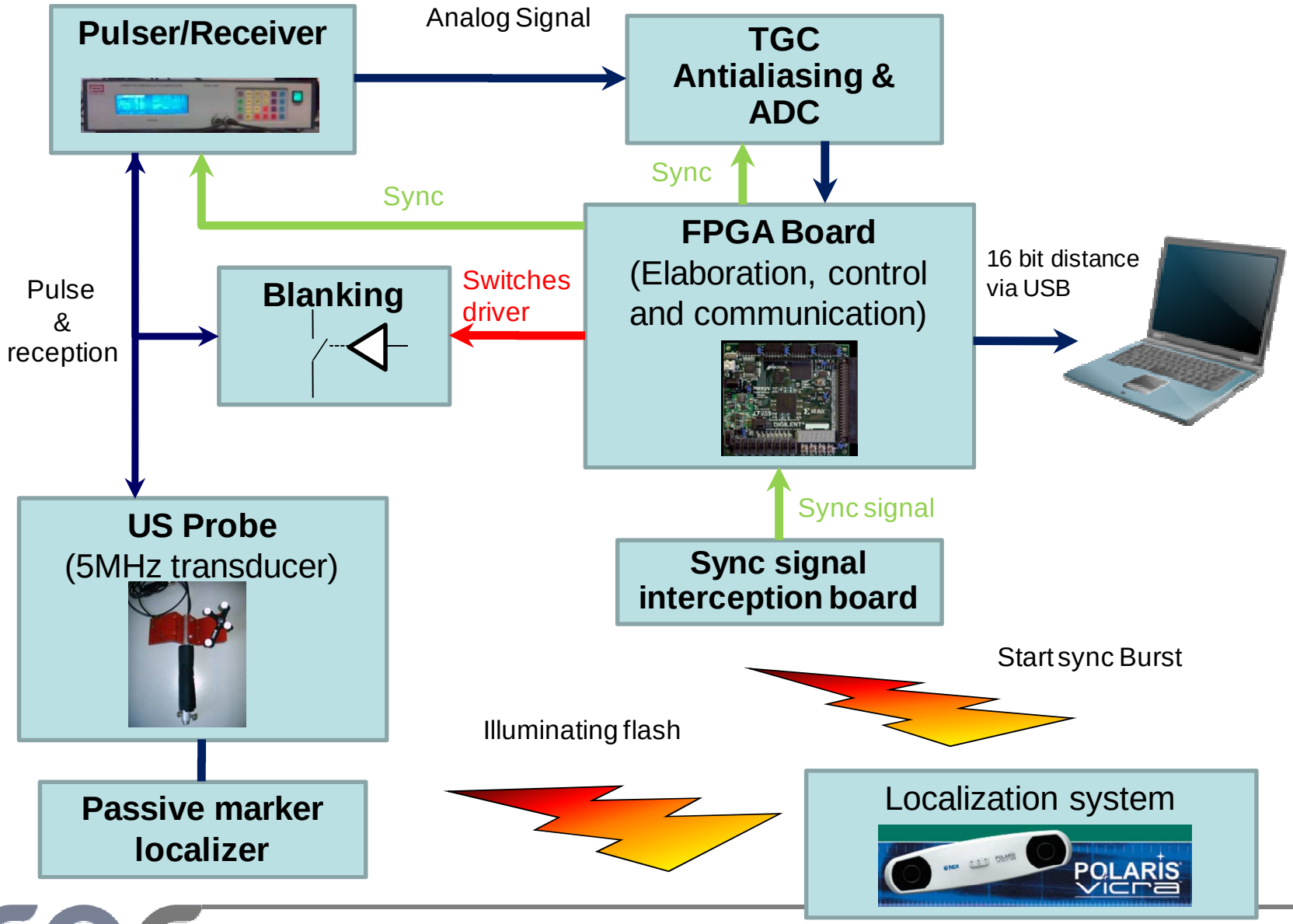
Optical localization system



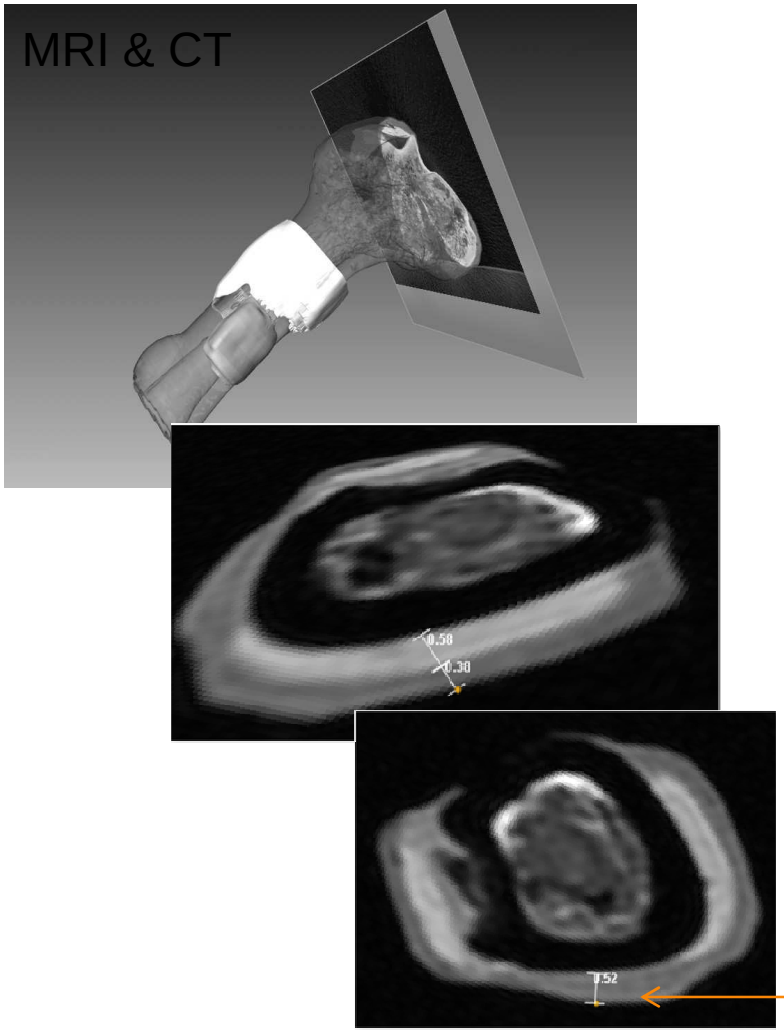


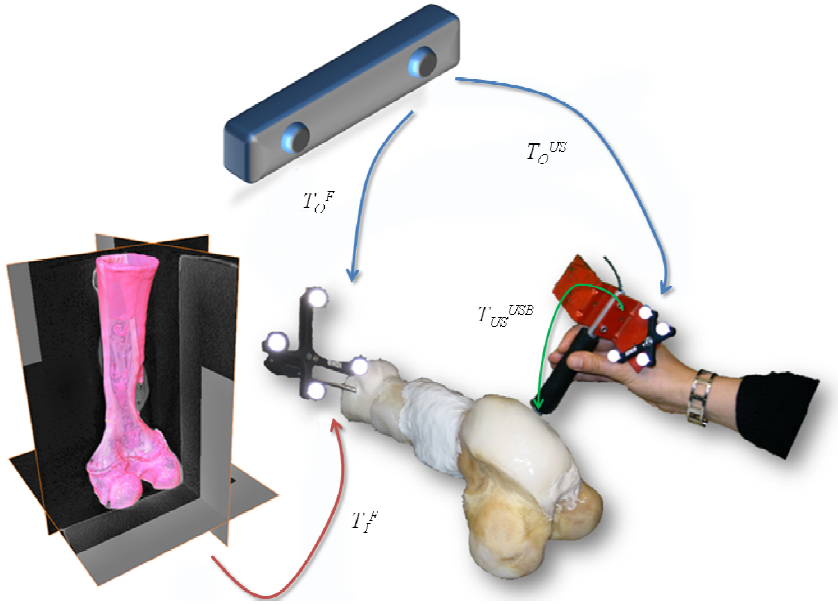
- No bone surface palpation
- Invasiveness reduction

The developed system



Methods - silicone layer thickess validation



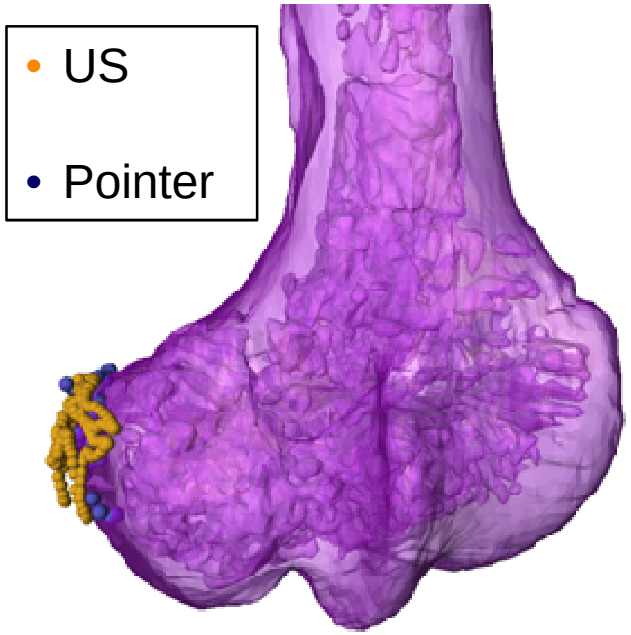


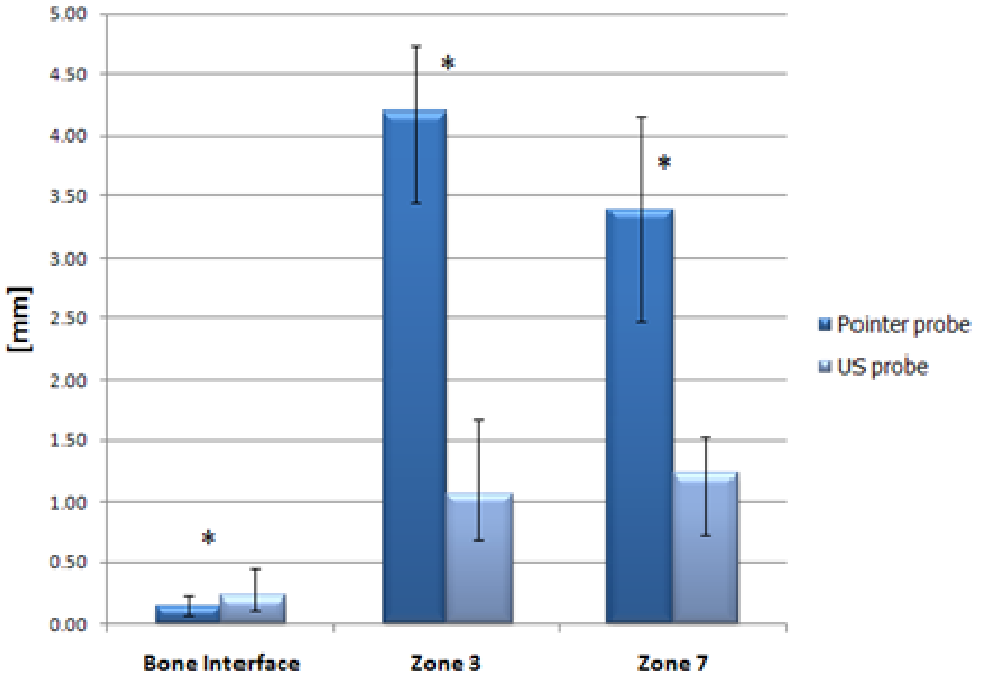
- After calibration position of the probe tip and beam direction in the imaging space is known (after ICP).
- It's possible to **measure thickness** of each silicone layer with oblique slices and compare those thickness with the ones calculated with US (velocity of sound is known from characterization)

Results – Overall US system vs Pointer

- On **exposed surfaces** (Bone Interface), the **tracked pointer** shows a median distance value of 0.14mm which is significantly **better** than the US probe value (0.21mm median value), but which is still acceptable.

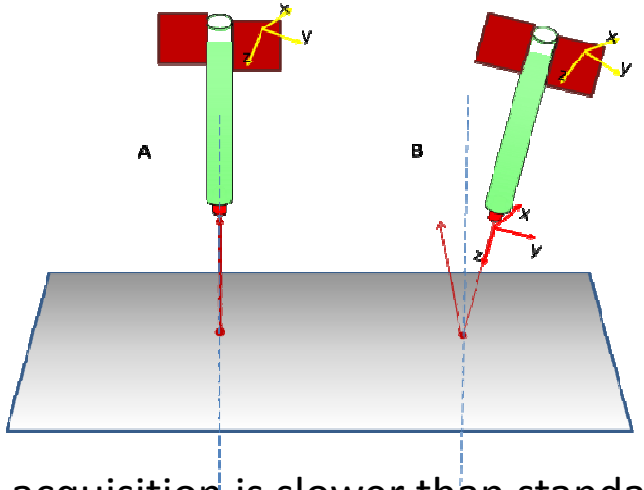
- In the phantom **regions covered** by silicone, the **US probe** behaves significantly **better** (max median value 1.2 mm) compared to the pointer.





Conlusions

- A-mode signal detection allows for **real-time surface points detection.**
- Accuracy tests of the whole system showed that the US probe acquisition behaves significantly better (max median value 1.2 mm vs. 4.2mm) compared to the acquisition with pointer.
- The tested system can considerably increase accuracy of registration and biomechanical point computation
- Perpendicularity problem → further development



- Problem: A-mode acquisition is slower than standard pointer points acquisition

Conlusions

Future developments:

- system testing in vivo during surgical procedure
- Perpendicularity check / feedback
- US real time velocity correction for each soft tissue, to improve distance detection

Thanks for your attention!