



**Bioengineering
Department**

**NeuroEngineering
and
medical AI Robotics
Lab**



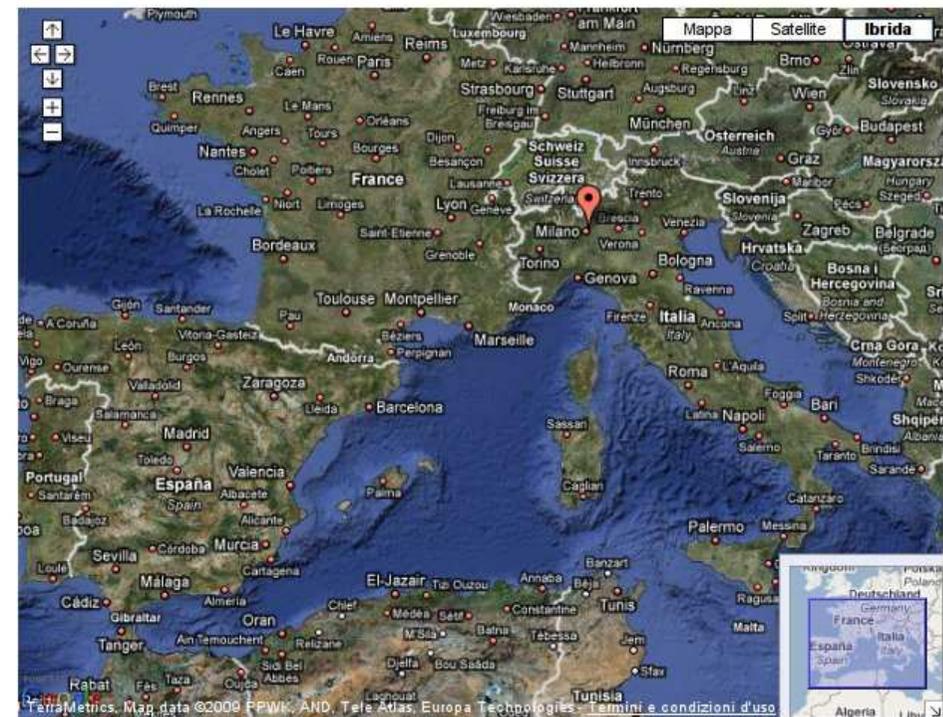
A-mode ultrasound acquisition system for computer assisted orthopaedic surgery

...and other

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Neuroengineering and medical robotics laboratory

www.biomed.polimi.it/nearlab



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2 main projects

BONUS system

Computer assisted orthopaedic surgery

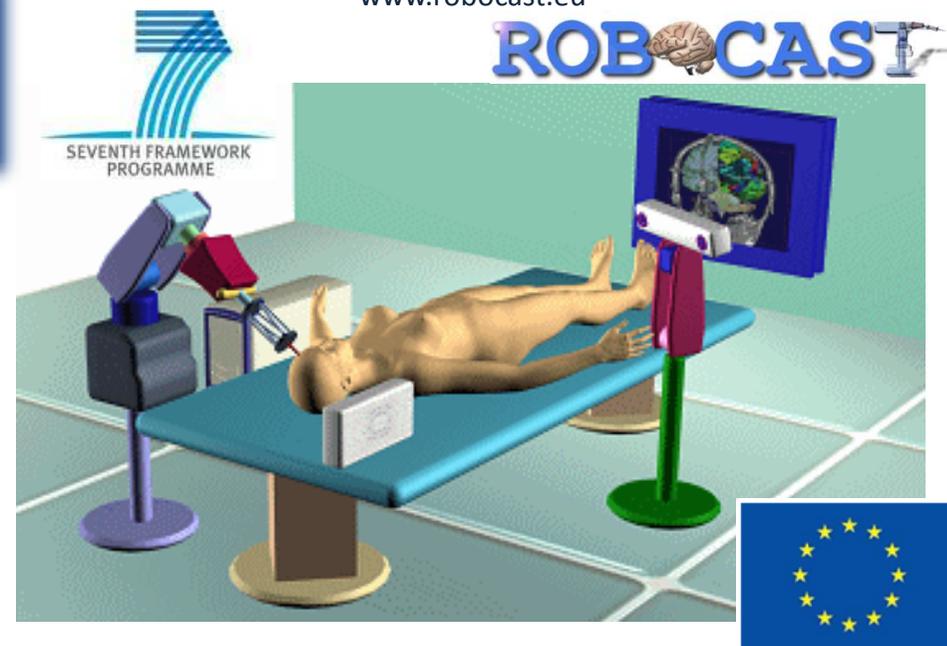


ROBOCAST

Keyhole neurosurgery

ROBOT and sensors integration for Computer Assisted Surgery and Therapy

www.robocast.eu



ROBOCAST Project

✓ Bioengineering Department Politecnico di Milano, Italy
 ✓ Department of Neurological and Vision Sciences - University of Verona, Italy
 ✓ SIRSLab - Robotics and System Lab - University of Siena, Italy
 ✓ Department of Mechanical Engineering and the Institute of Biomedical Engineering - Imperial College, London, UK
 ✓ Prosurgics Ltd, UK
 ✓ Laboratory for CAS and Medical Image Processing - The Hebrew University of Jerusalem, Israel
 ✓ Faculty of Mechanical Engineering - Technion, Israel Institute of Technology, Haifa, Israel
 ✓ Mazor Surgical Technologies Ltd, Israel
 ✓ Lehrstuhl für Computeranwendungen in der Medizin, Institut für Informatik - Technische Universität München, Germany
 ✓ Institute for Process Control and Robotics - Universität Karlsruhe (TH), Germany
 ✓ Finanziamenti Unione Europea S.r.l., Milan, Italy

Map coordinates: Puntatore 42°50'00.01" N 12°50'00.00" E elev. 593 ft
 © 2009 Europa Technologies, © 2009 Tele Atlas, © 2009 Basarsoft, © 2009 Geocentre Consulting
 Streaming 100%
 Alt. 3039.76 mi
 Google™

The Concept

KEYHOLE NEUROSURGERY

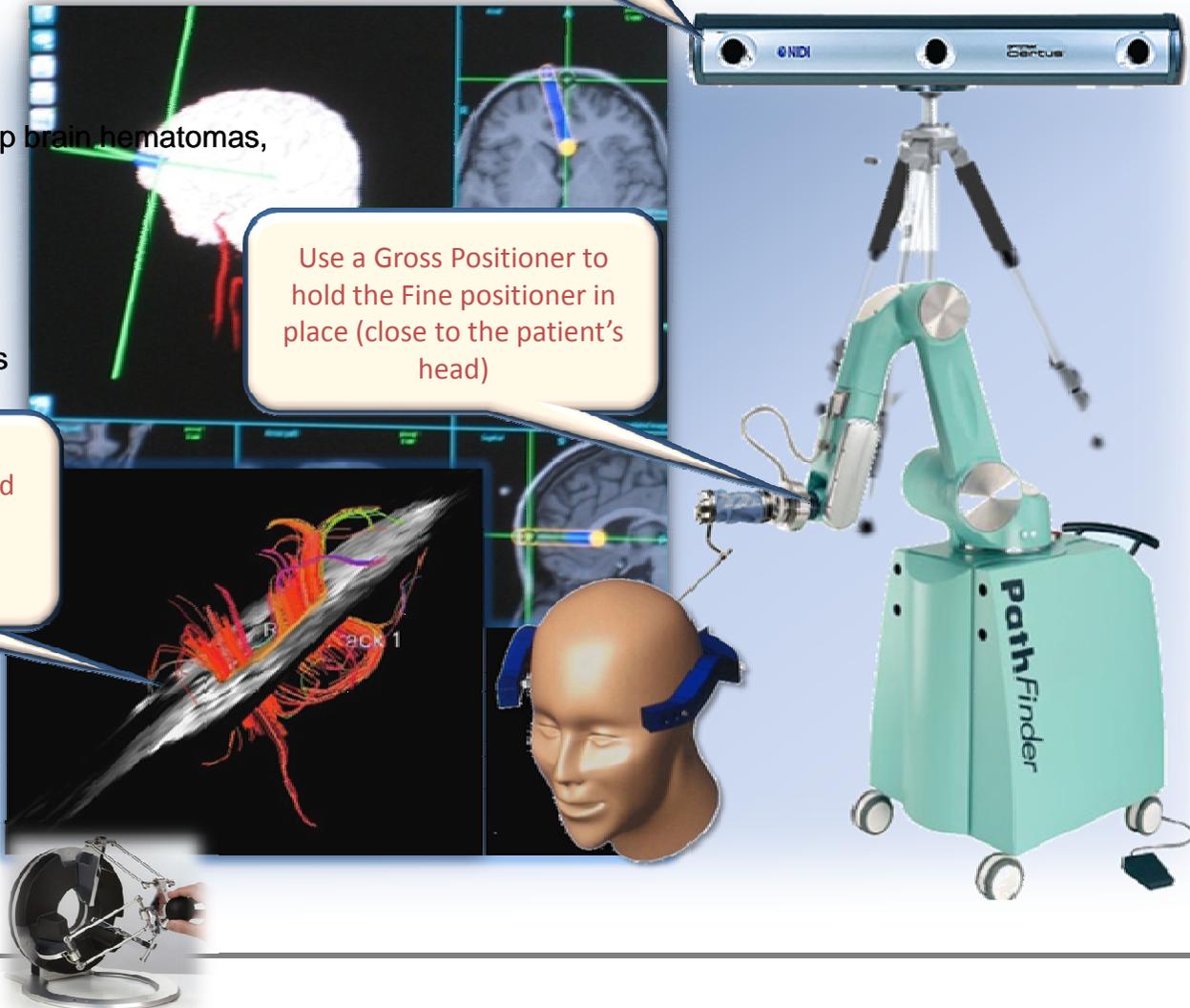
- ✓tumour biopsies,
- ✓treatment of hydrocephalus,
- ✓aspiration and evacuation of deep brain hematomas,
- ✓‘Ommaya’ catheter insertion,
- ✓deep brain stimulation,
- ✓and minimal access craniotomies

Closed loop control with external sensors (optical electromagnetic)

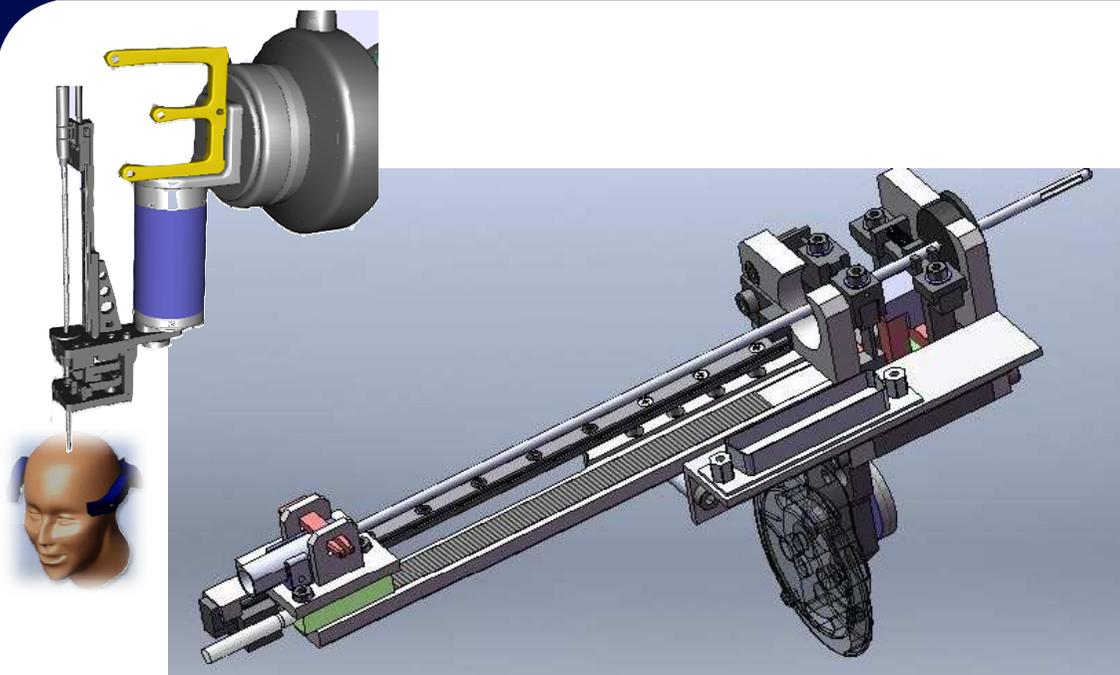
Use a Gross Positioner to hold the Fine positioner in place (close to the patient's head)

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

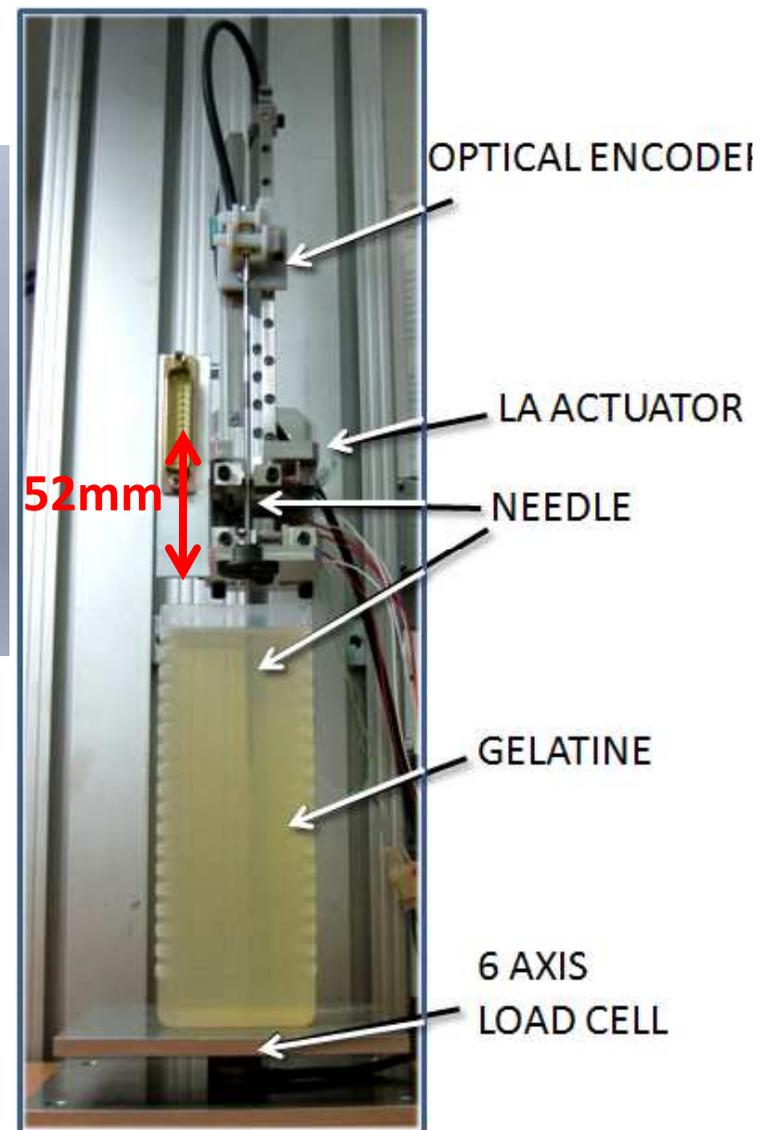
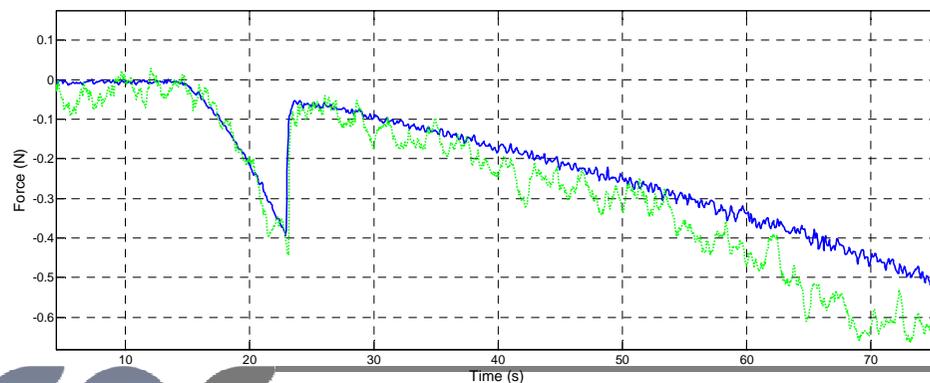
Surgeon is handling a haptic interface in order to perform the needle insertion



Force sensing

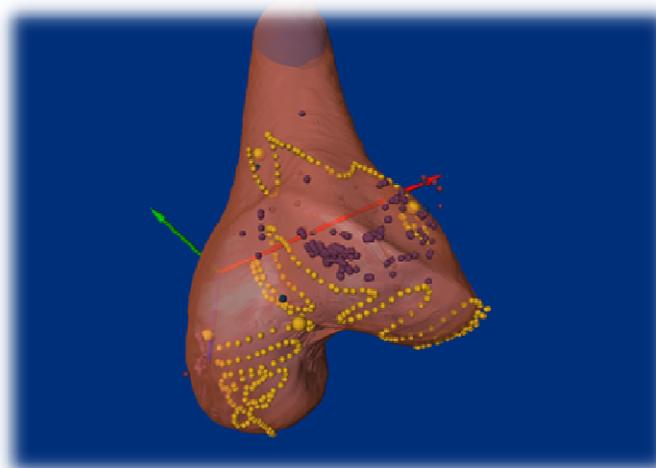


Credit: Ilya Dyagilev, MRL laboratory,
Technion University, Haifa (Israel)



Aim

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

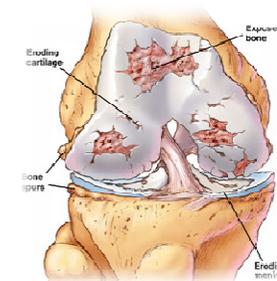


- ... in computer assisted orthopaedic surgery.

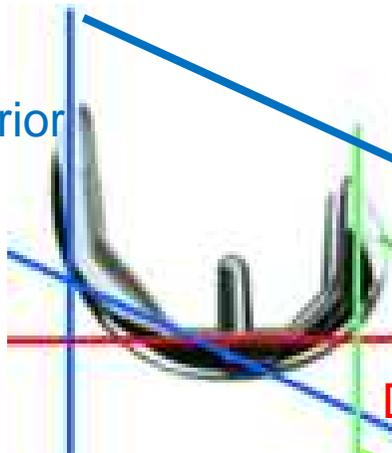


Knee prosthesis

arthrosis
70% aged (>65 years)
population affected

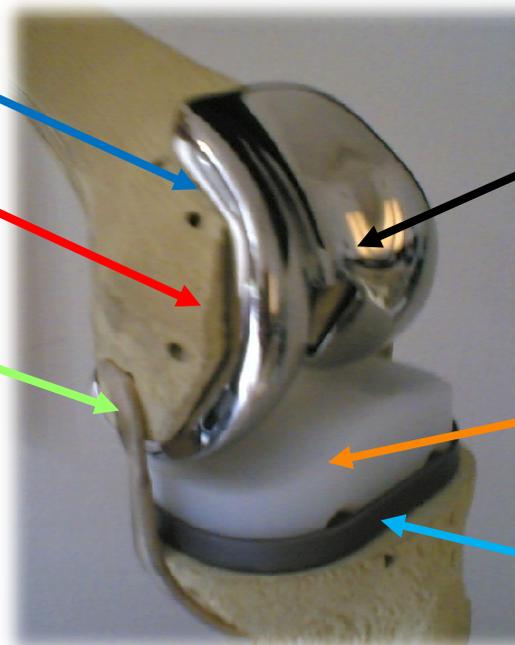


Anterior cut



Distal cut

Posterior cut



Femoral component

Liner

Tibial component

Thanks to Lima L.to, Udine Italy

- Requirements on cuts:

- Ex. The plane of the distal cut has to be perpendicular to mechanical axe of the femur



Computer assisted orthopaedic surgery

Surgical navigation system



Optical localization system
Vicra NDI, Canada

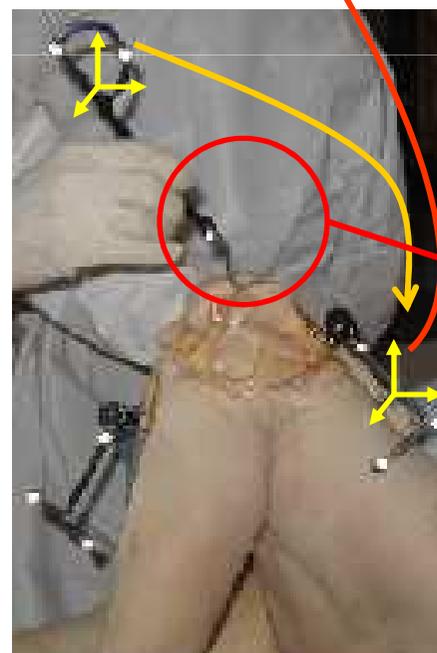


Reference frames

Visual feedback



Registration



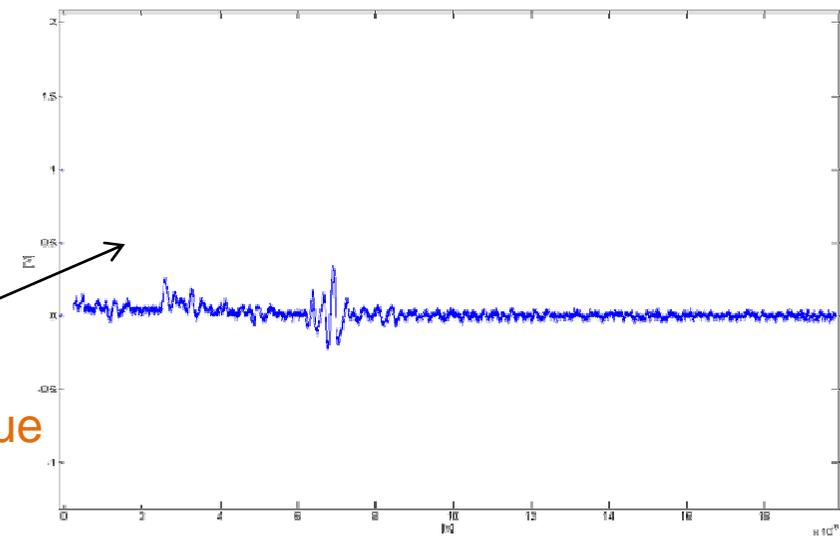
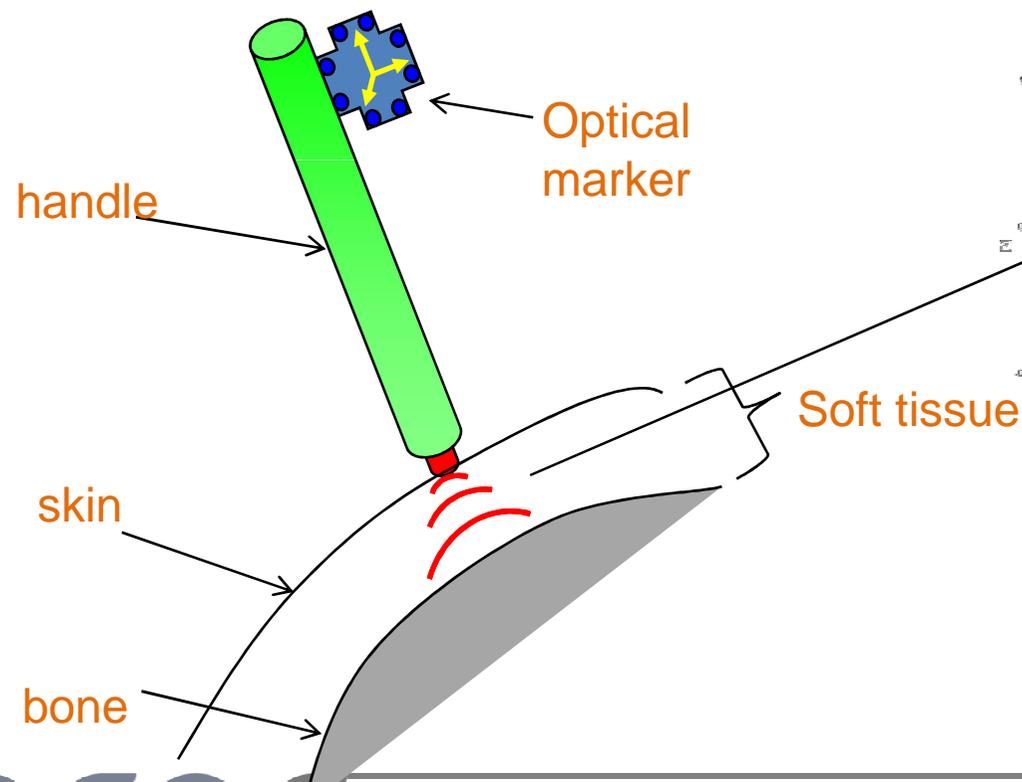
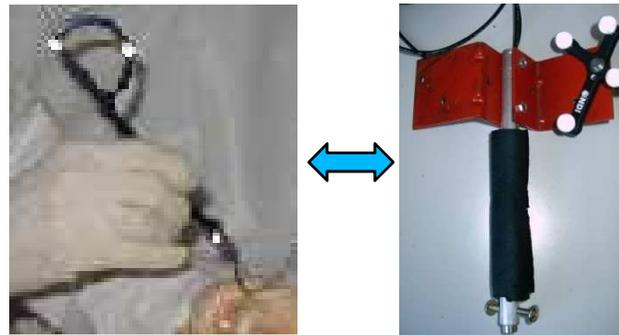
Localization error up to 7mm
(Yau et al. 2005)

Affecting correct
prosthesis insertion

Why ultrasound system?

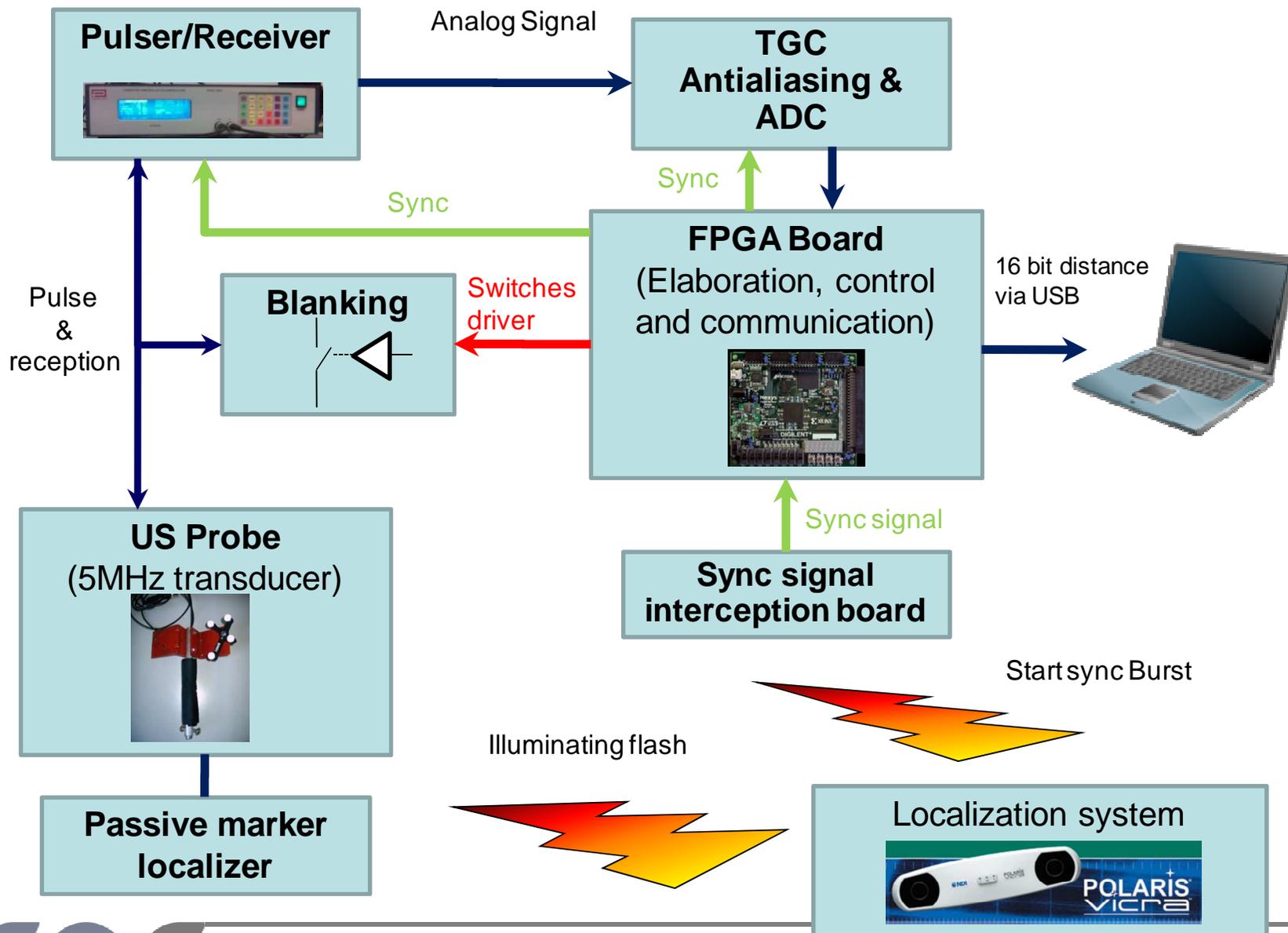


Optical localization system

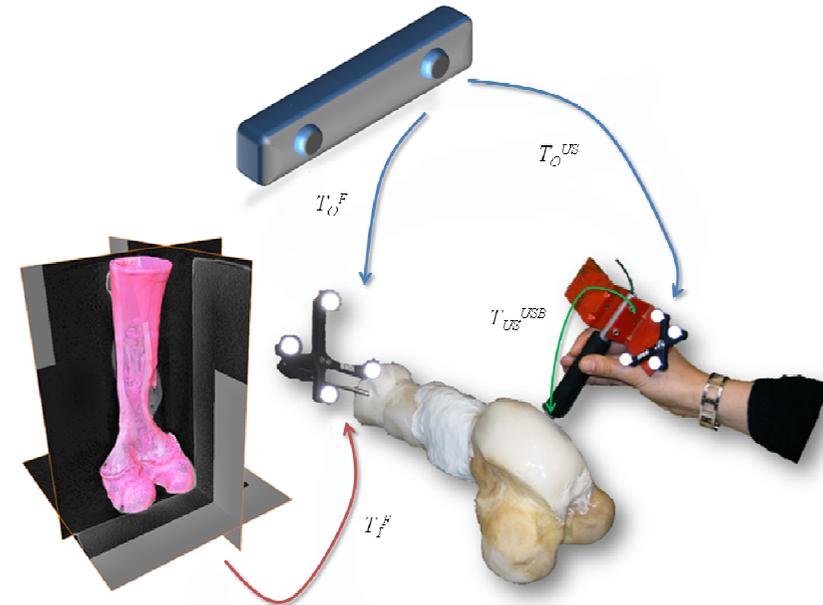
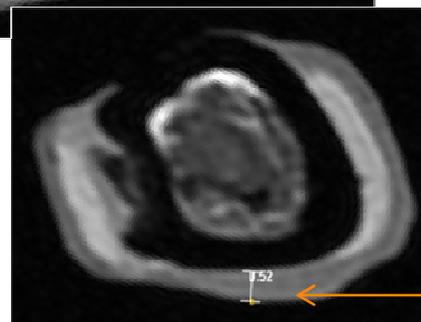
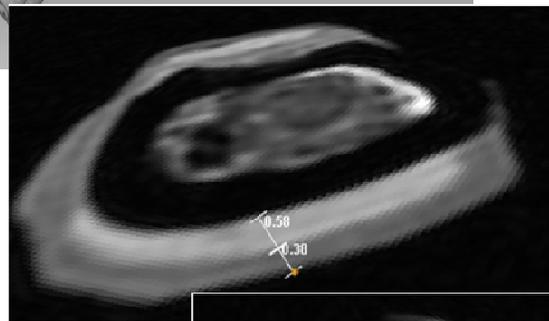
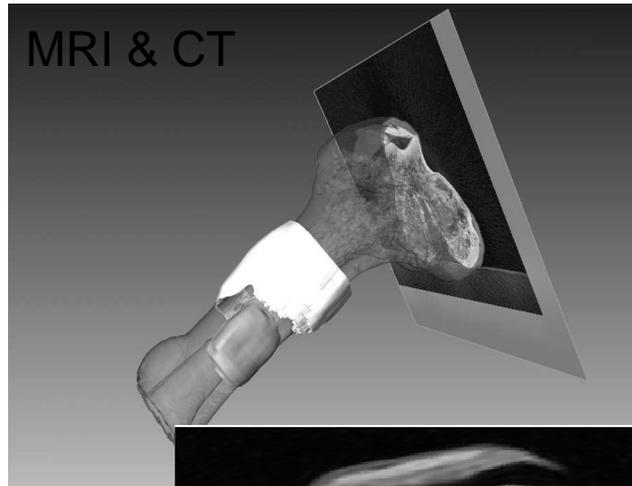


- No bone surface palpation
- Invasiveness reduction

The developed system



Methods - silicone layer thickness validation

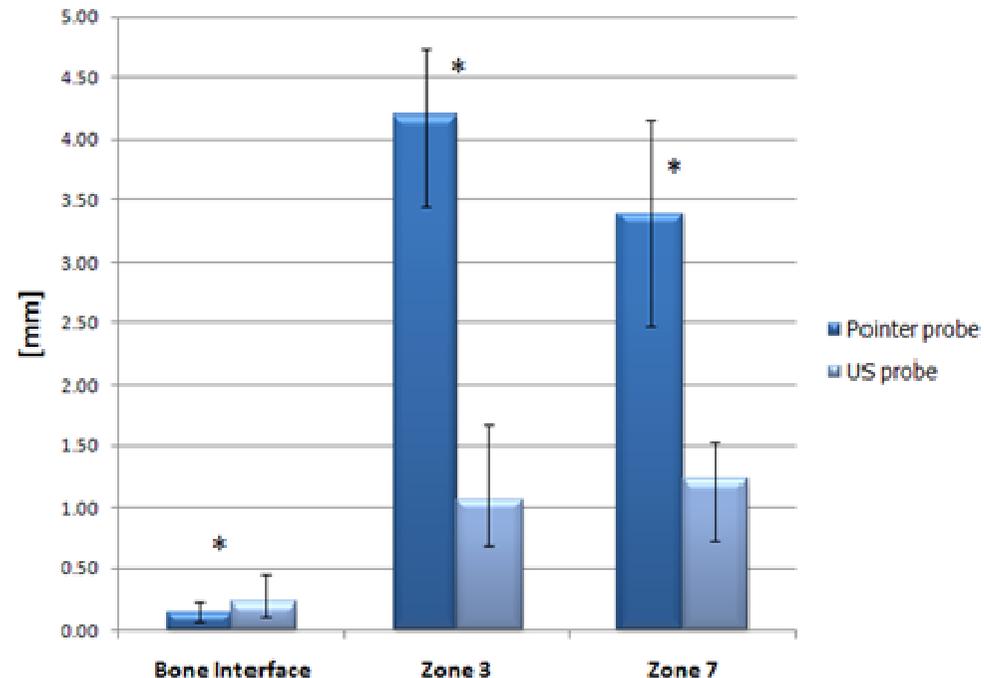
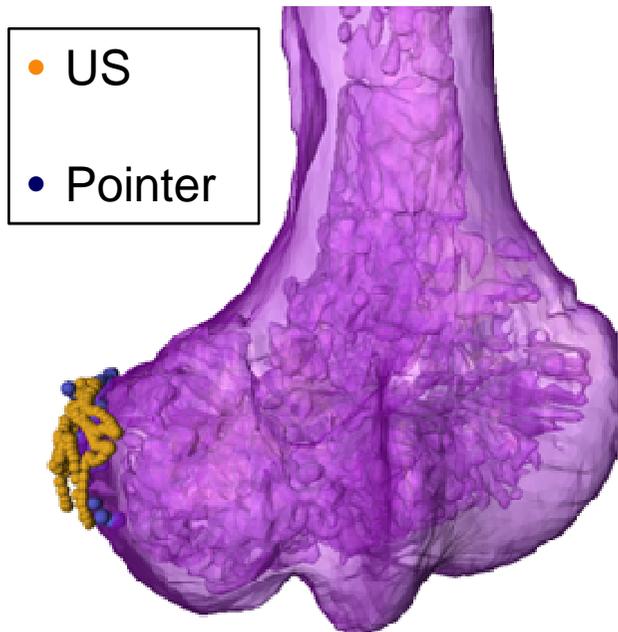


- After calibration position of the probe tip and beam direction in the imaging space is known (after ICP).
- It's possible to **measure thickness** of each silicone layer with oblique slices and compare those thickness with the ones calculated with US (velocity of sound is known from characterization)

Results – Overall US system vs Pointer

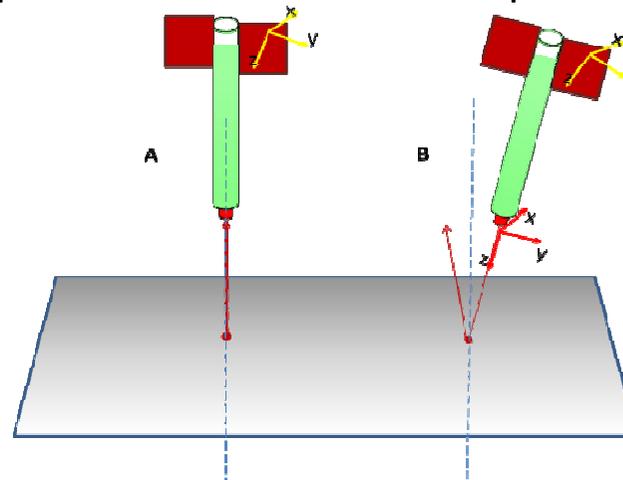


- On **exposed surfaces** (Bone Interface), the **tracked pointer** shows a median distance value of 0.14mm which is significantly **better** than the US probe value (0.21mm median value), but which is still acceptable.
- In the phantom **regions covered** by silicone, the **US probe** behaves significantly **better** (max median value 1.2 mm) compared to the pointer.



Conclusions

- 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



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!