


INAIL
Centro Profesi



Upper extremity 3D kinematics measured through inertial & magnetic sensors

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Framework

Shoulder and elbow impairment

INAIL services

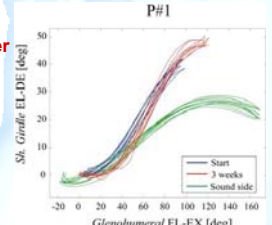


Need

Diffuse quantitative motion analysis to 200 therapist offices

↓

objectively and quantitatively monitor the evolution of shoulder and elbow mobility



Problem statement



- a therapist office is a **small room**
- markers missing and occlusions → time-consuming post-processing
- high cost

Aim

1)

2)

Ambulatory assessment of shoulder and elbow 3D kinematics

Topic

1) Hardware chosen

2) Protocol developed

3) Two application scenarios

Hardware - IMMS

Inertial & Magnetic Measurement Systems

InterSense (USA)

Microstrain (USA)

Xsens Technologies (NL)

Hardware - IMMS

MT9B – Xsens Technologies (NL)

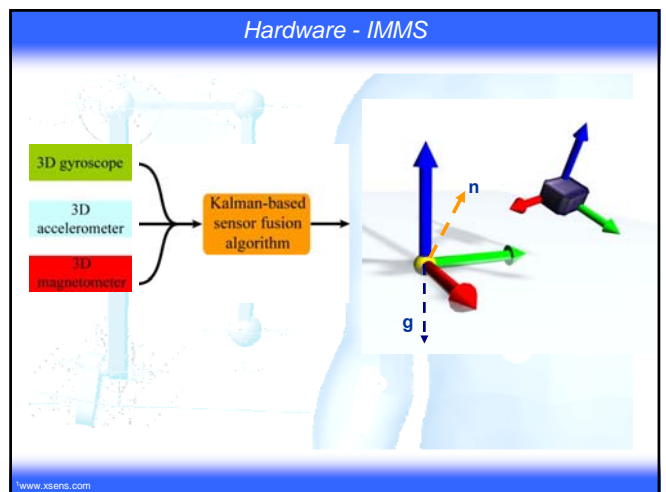
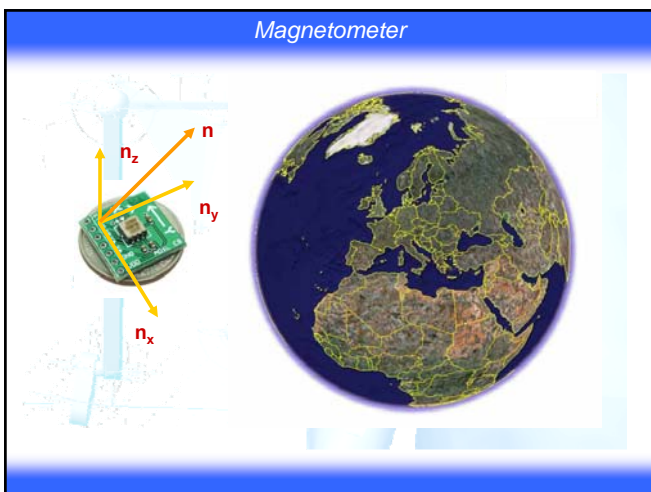
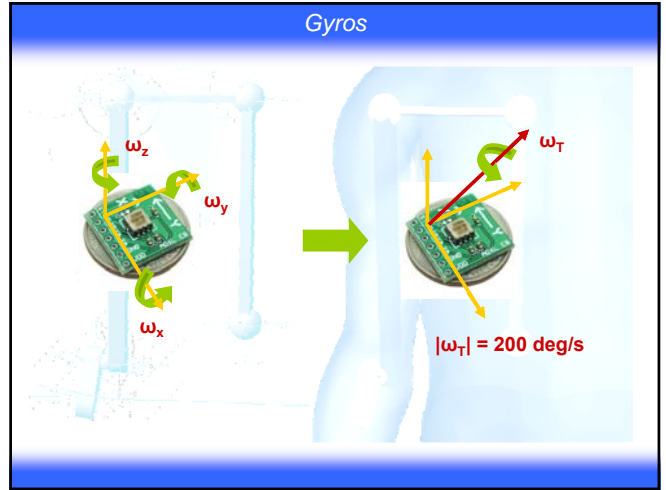
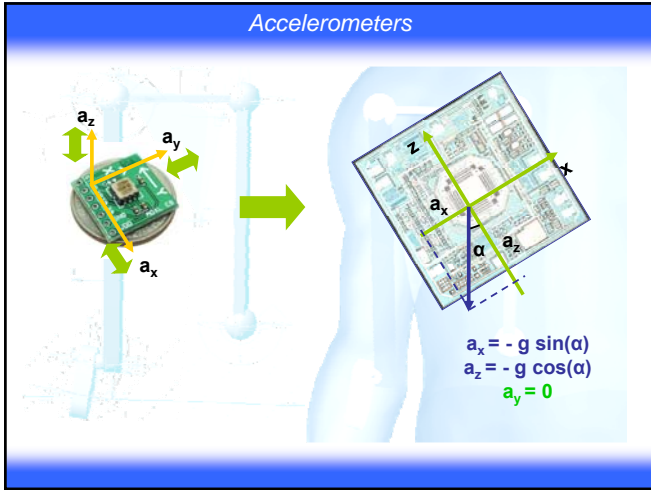
- 38g
- 39x54x28mm
- SoR misalignment w.r.t. box <math><3^\circ</math>
- ~ 1000€/sensor

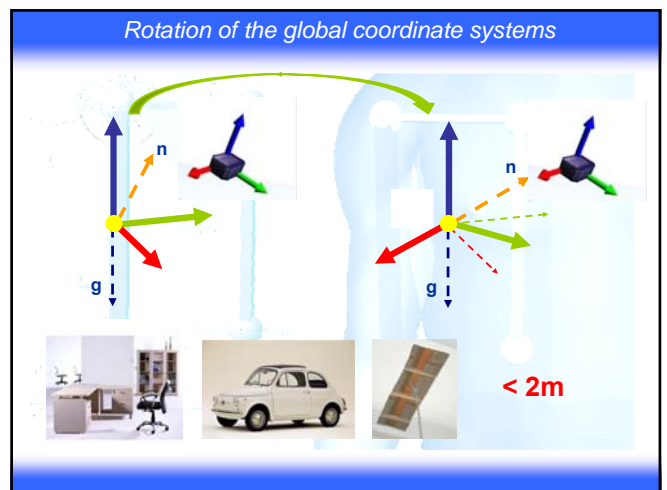
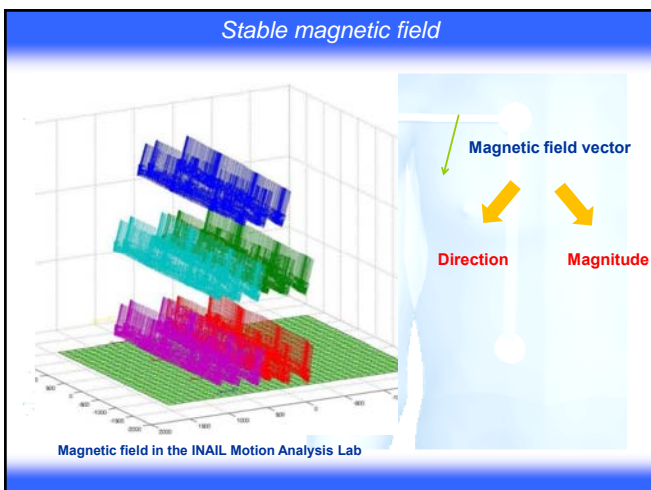
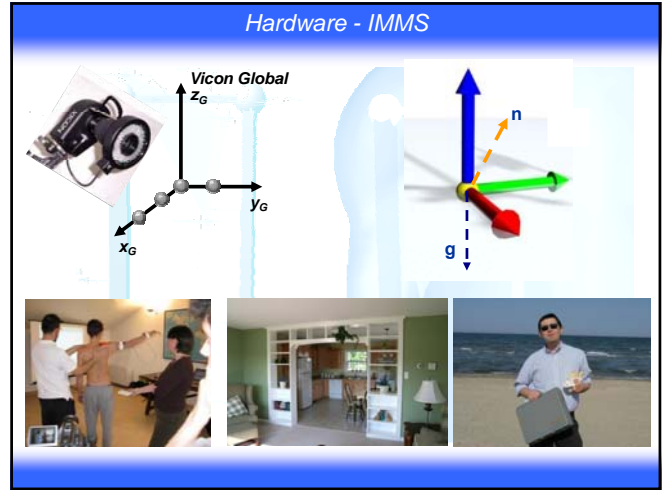
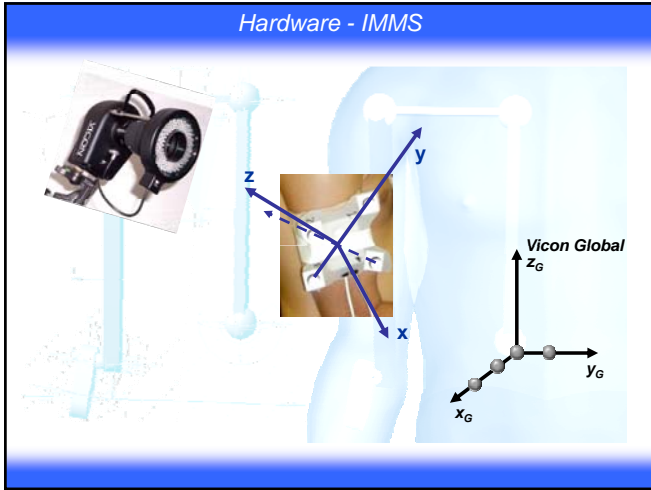
3D gyroscope

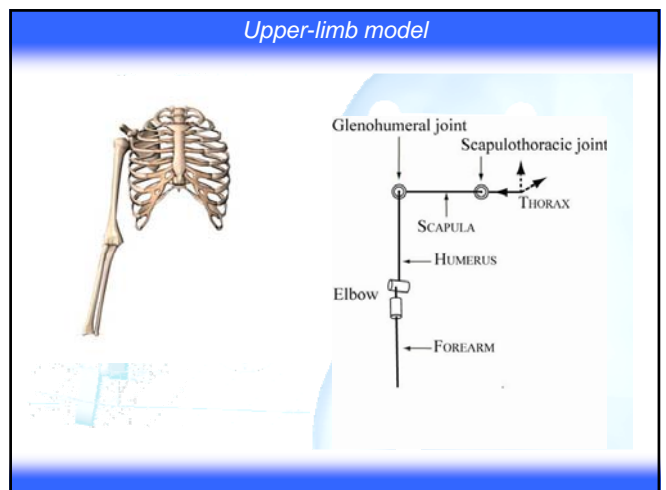
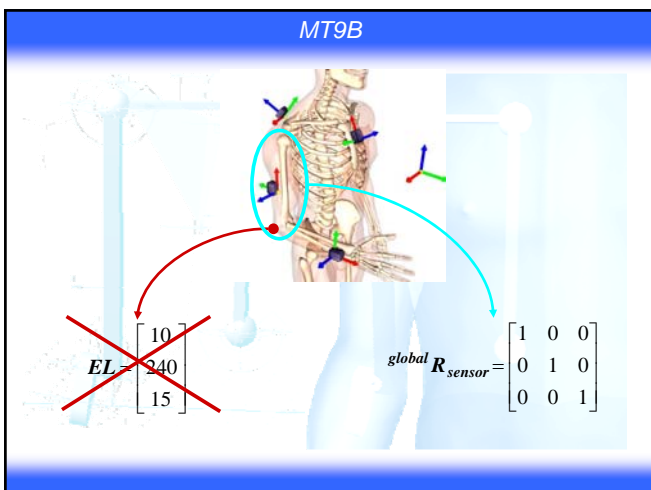
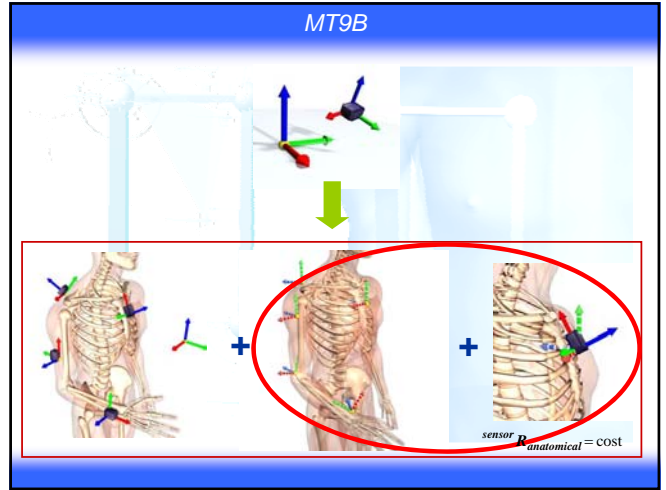
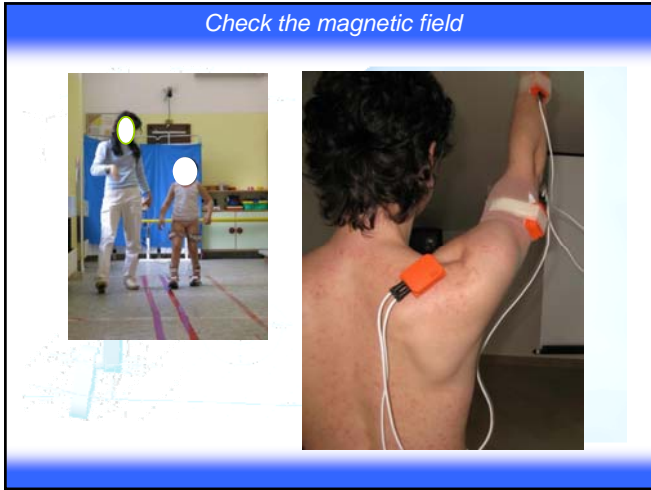
3D accelerometer

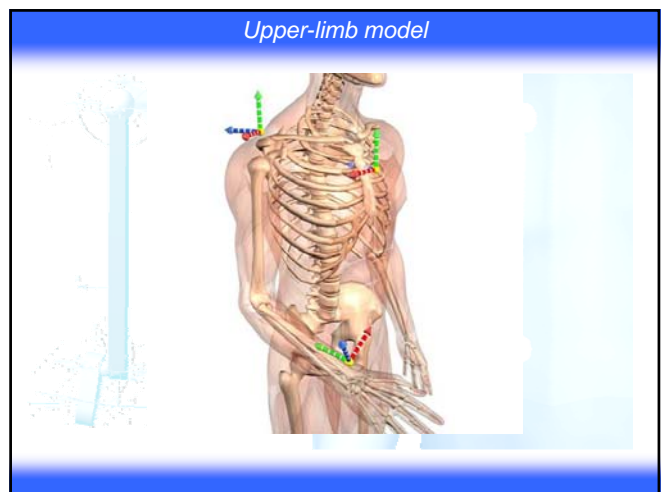
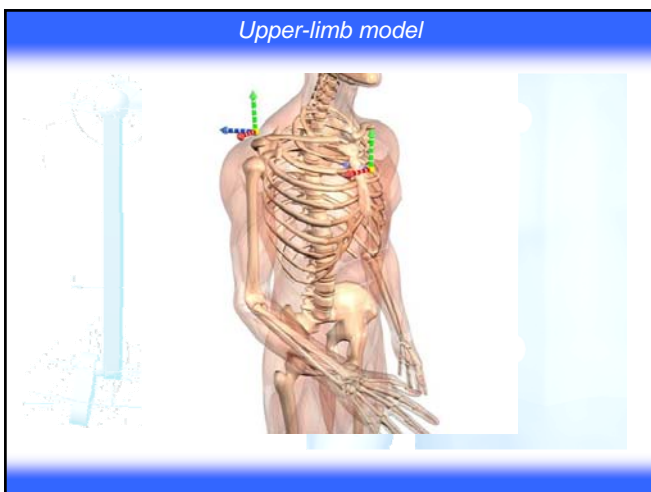
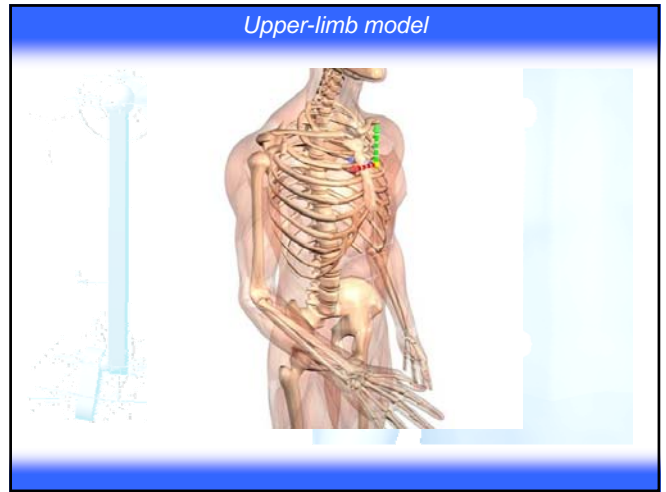
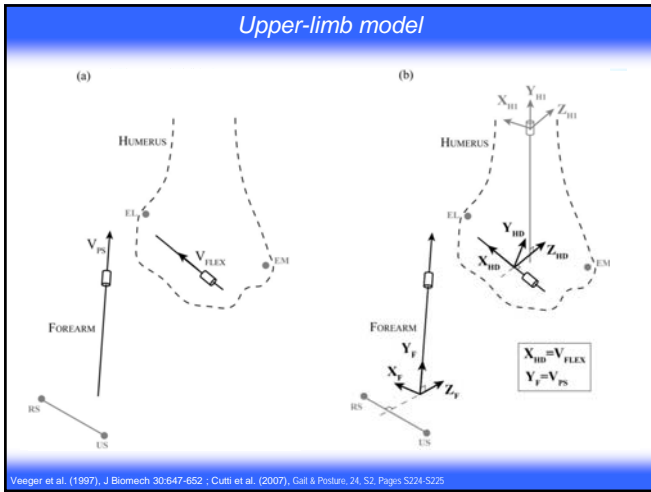
3D magnetometer

www.xsens.com

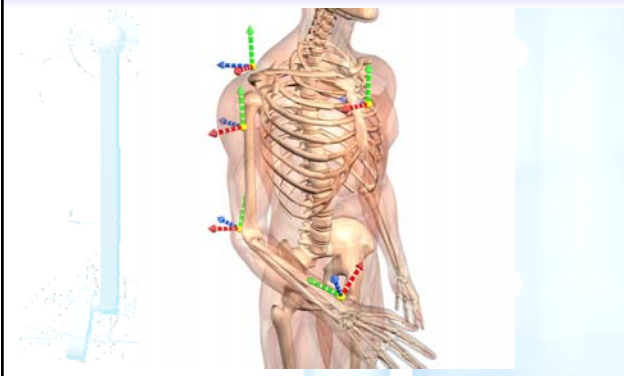








Upper-limb model

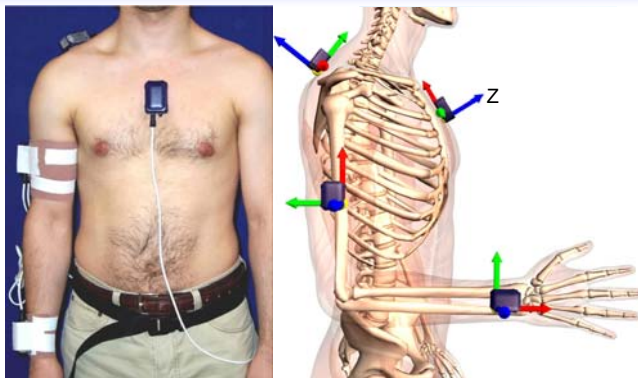


Protocol steps

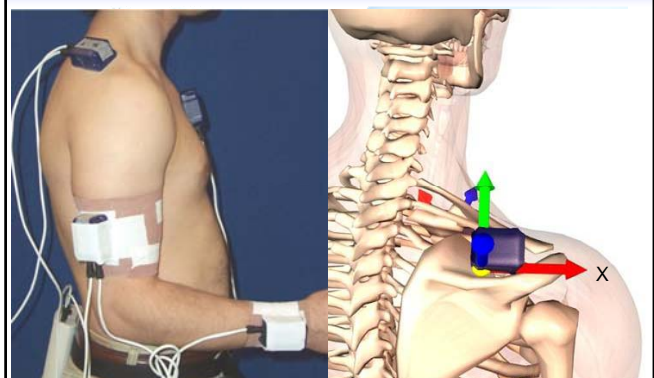
The protocol to define the **5 anatomical/functional CSs** and express them in the **CSs of the sensors** is based on **3 steps**:

- 1. Position** the sensors over the subject's body, to align some of the sensors' axes along relevant anatomic directions
- 2. Measure** the sensors' orientation with the **subject standing still**
- 3. Measure** the sensors' orientation while the **subject performs one pure flexion-extension** and one **pure prono-supination of the elbow**

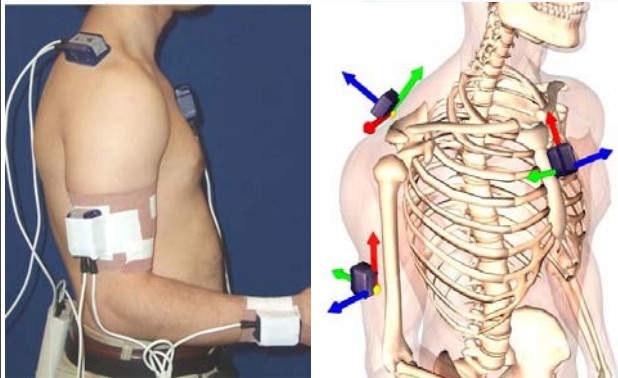
Step 1 – sensor placement



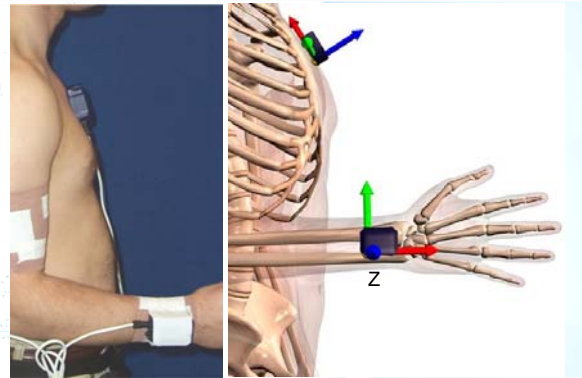
Step 1 – sensor placement



Step 1 – sensor placement



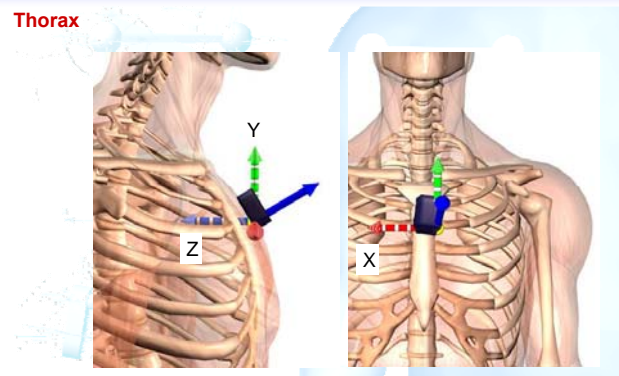
Step 1 – sensor placement

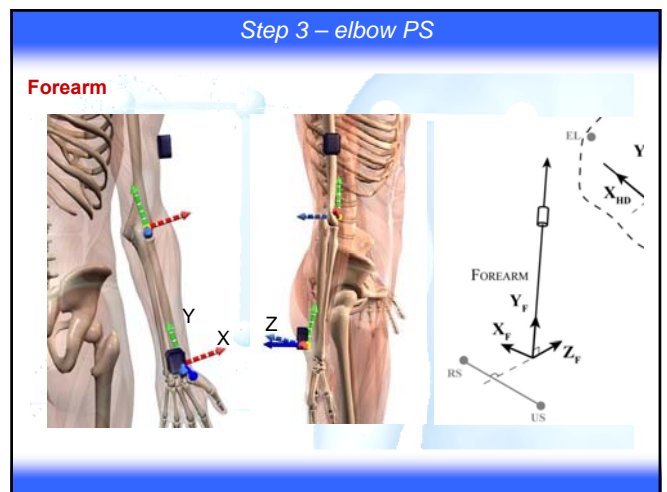
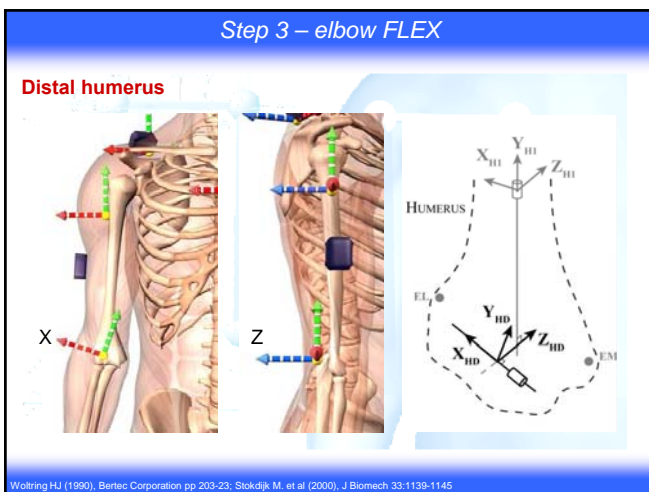
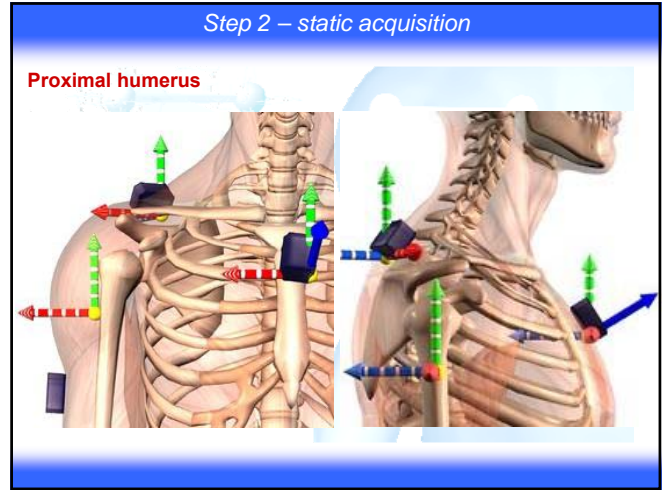
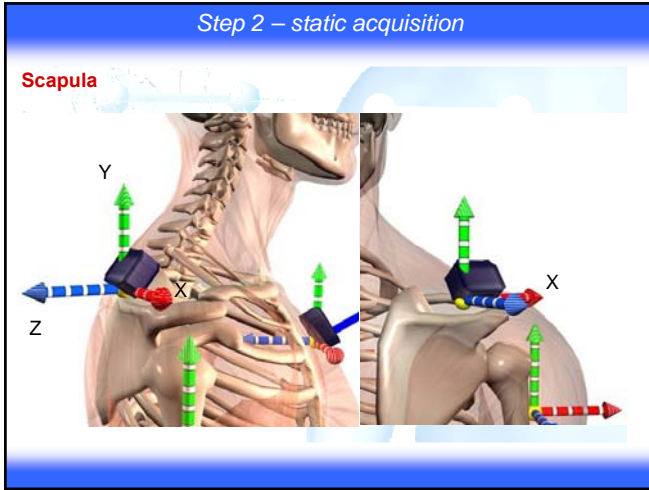


Step 2 – static acquisition

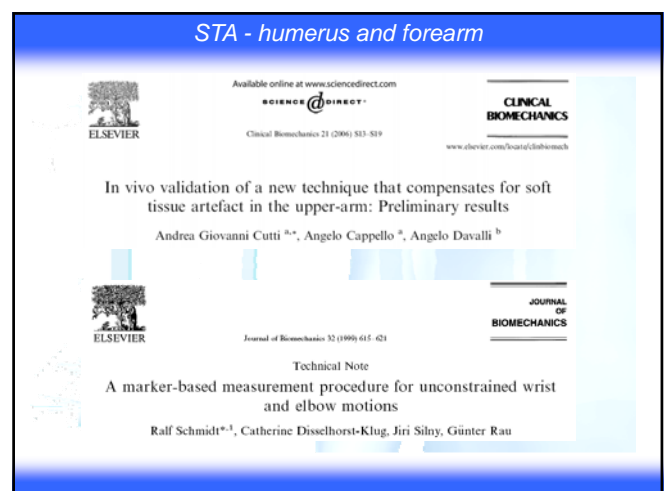
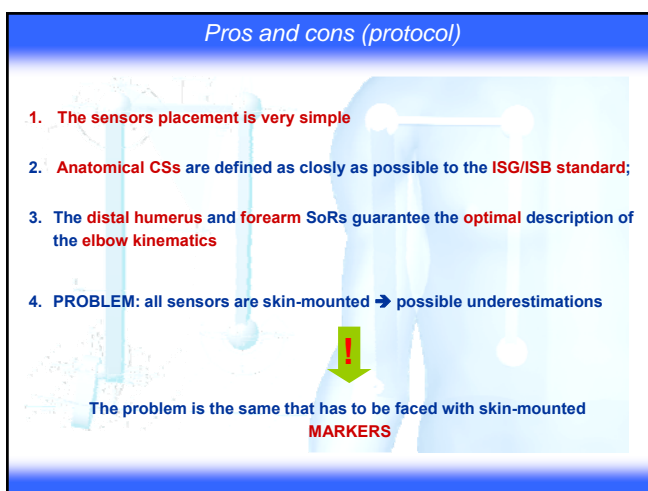
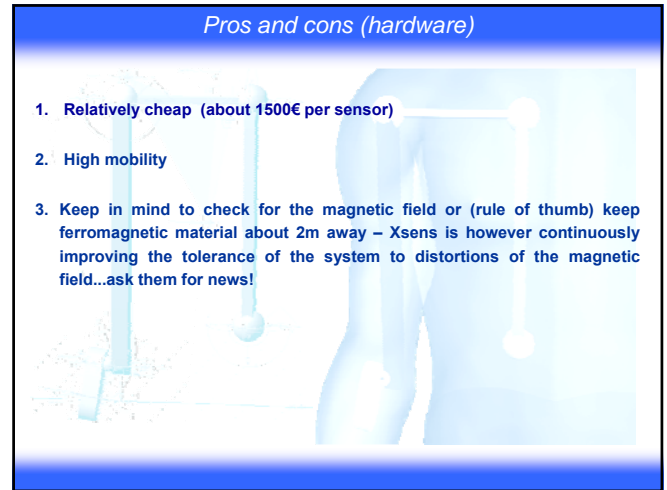
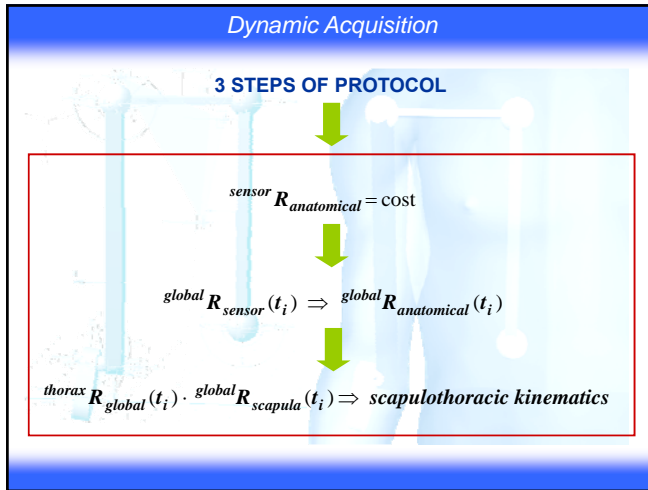


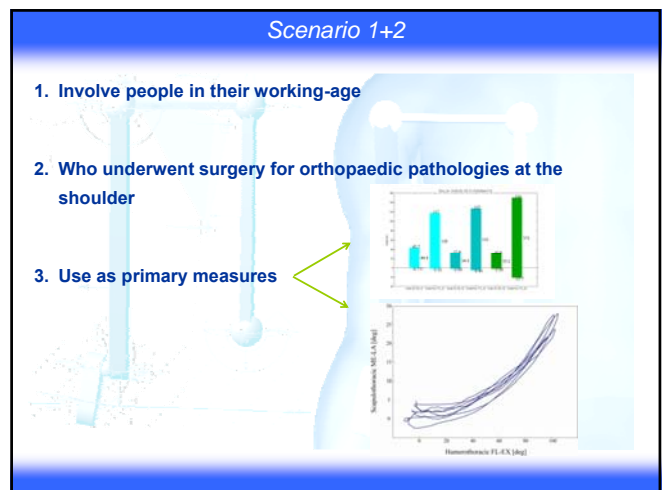
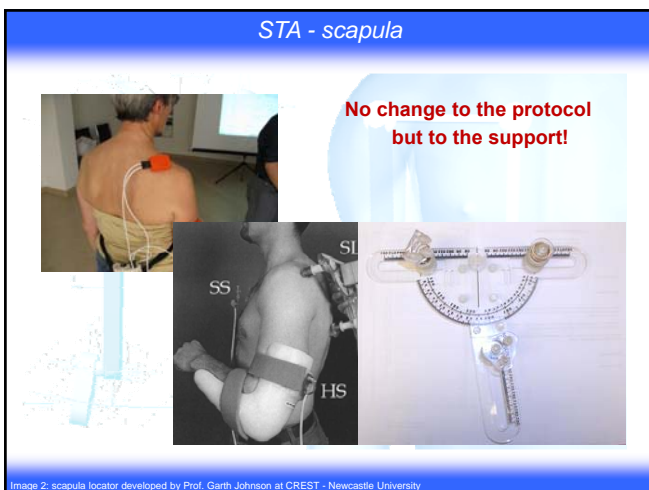
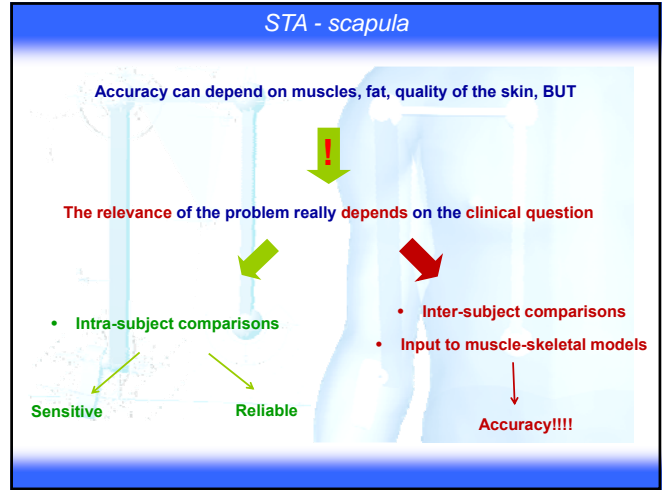
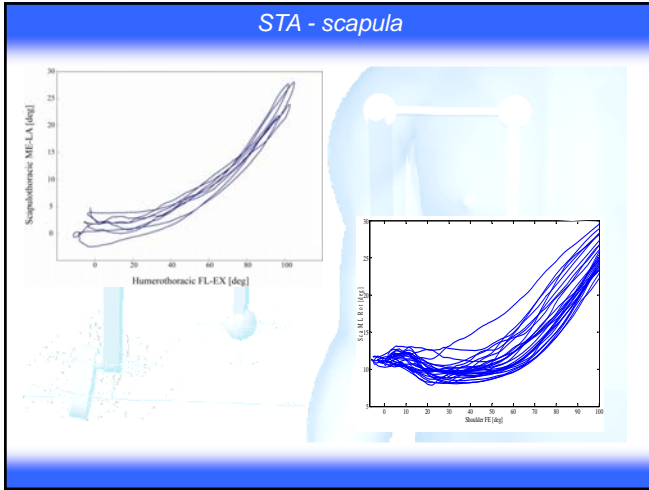
Step 2 – static acquisition





Woltring HJ (1990), Bertec Corporation pp 203-23; Stokdijk M. et al (2000), J Biomech 33:1139-1145





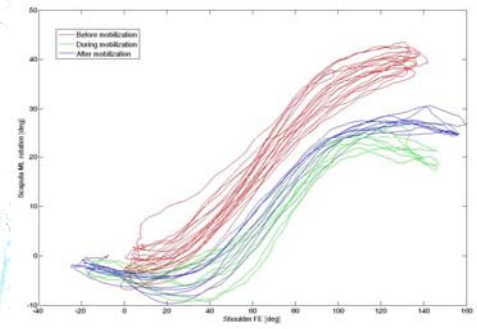
Scenario 1

Video

1. The software lets the patient and the therapist **see the sound side pattern** and allows the patient to follow it with the affected
2. The system + protocol allows to "Put the hands on the patient" and let **see the movement when controlled by the therapist, with an actual reference**

Scenario 2

Video



Conclusion

IMMS + protocol may become not just a post-exercise measurement tool but a "during mobilisation" support with video bio-feedback

Are you thinking...?

1. Given the protocol, which is the **accuracy of the MT9B** when used to measure the upper-limb kinematics in comparison with a Vicon?
2. Are the **anatomical / functional coordinate systems** representative of the actual kinematics of the subject?
3. Which is the **inter-rater and intra-rater reliability** of the protocol?
4. Which kind of **activities** will you ask your patients to do?

Some answers in paper ...

Med Bio Eng Comput
DOI 10.1007/s11517-007-0296-5

ORIGINAL ARTICLE

Ambulatory measurement of shoulder and elbow kinematics through inertial and magnetic sensors

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Laura Rocchi · Angelo Davalli · Rinaldo Sacchetti

