Research activities in the

Medical Physics Lab-Simulation Center

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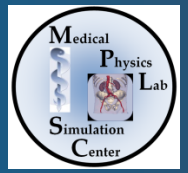
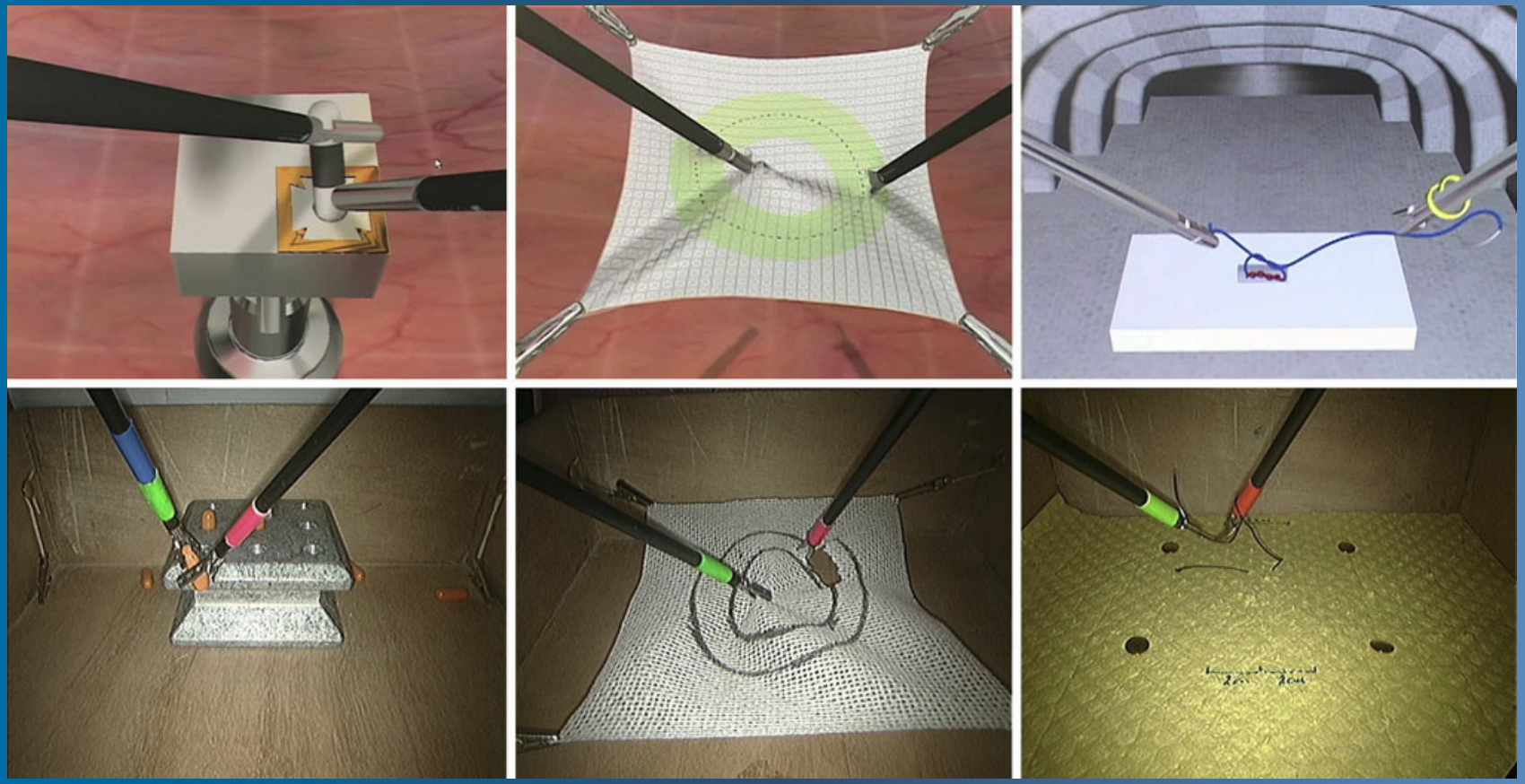


Research Directions

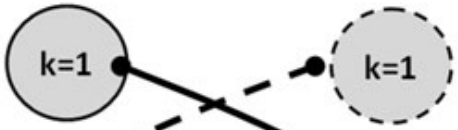
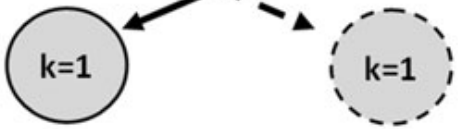
- Medical simulation:
  - curriculum development, learning curve estimation, virtual/physical reality simulation training
- Assessment of surgical dexterity
  - hand kinematics, hand motion signal modeling, surgical workflow analysis
- Image analysis studies
  - instrument tracking, augmented reality surgical simulation training (!)

Head-to-head comparison between VR and physical reality-based training



Loukas et al., Surg. Endosc. 2011

Study design

Study Phase	Training modality	
	VR simulator	Video Trainer
Equipment familiarization	Instructional tutorial	Instructional tutorial
Task familiarization	Trial performance of each task (randomized order)	Trial performance of each task (randomized order)
Pre-training Tasks performed in randomized order		
Training 12×peg transfer → 12×cutting → 12×knot tying		
Post-training Tasks performed in randomized order		
—— : VT group (n=22), - - - : VR group (n=22).		

Research findings

- Both modalities provided significant enhancement of the novices' performance.

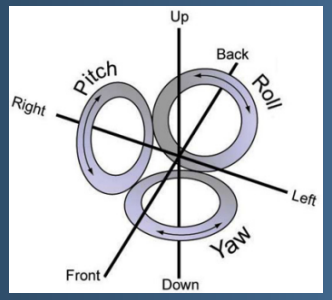
- The skills learned on the VR environment are transferable to the physical reality environment and vice versa.

- However…

  training with one modality does not necessarily mean a performance equivalent to that achieved with the other modality (*especially for complex skills such as knot-tying*)

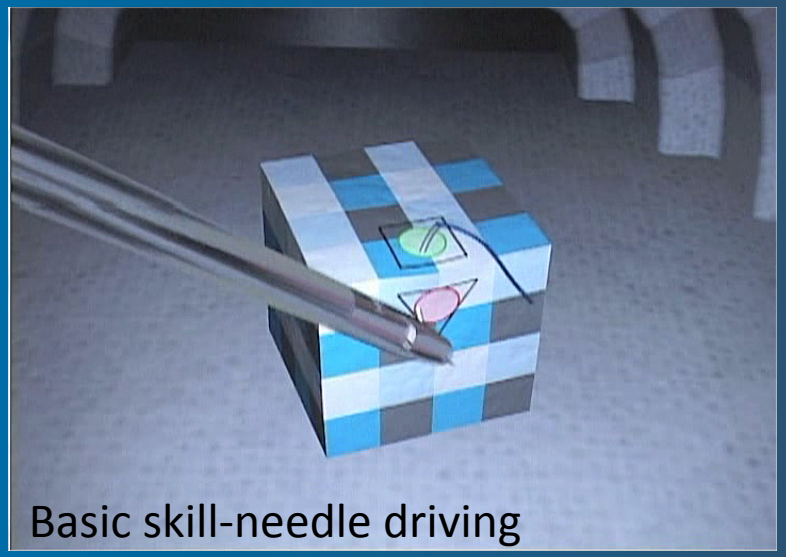
Hand kinematics analysis of surgical residents

- Objective: can we classify residents with different surgical experience? (e.g. beginners *vs* intermediates)
- Inclination sensors attached to the instruments:

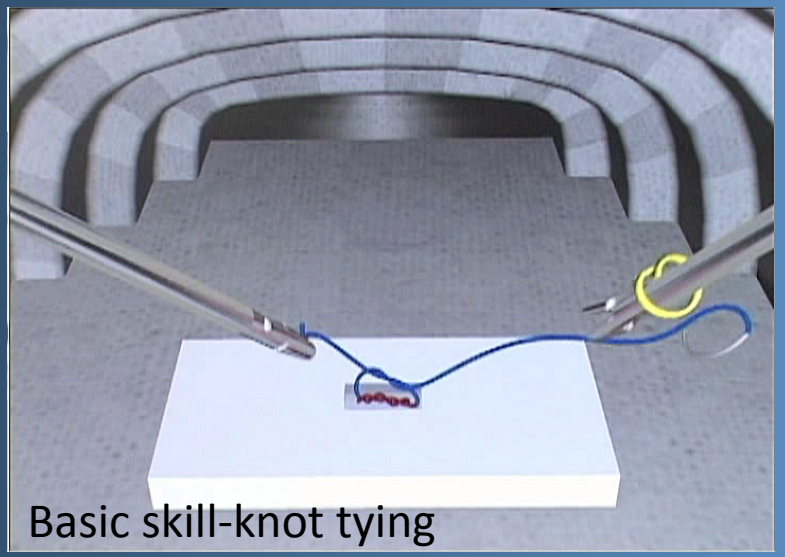


- The established approach employs HMM. We proposed Multivariate Autoregression (MAR) Models. Coefficients are classified with an ANN.
- Useful properties of MAR models: construction of Hand Motion Connection Networks

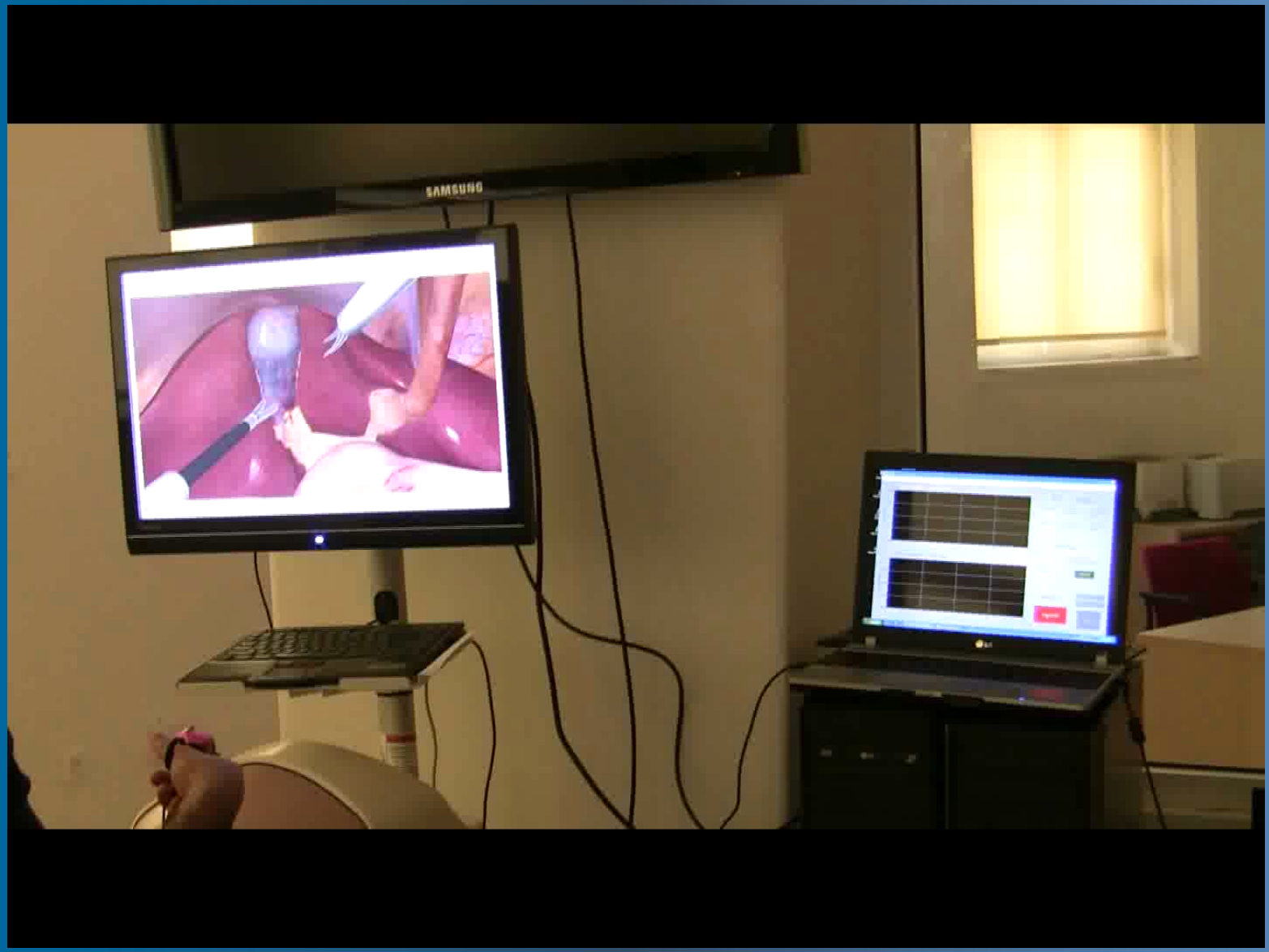
VR simulation tasks

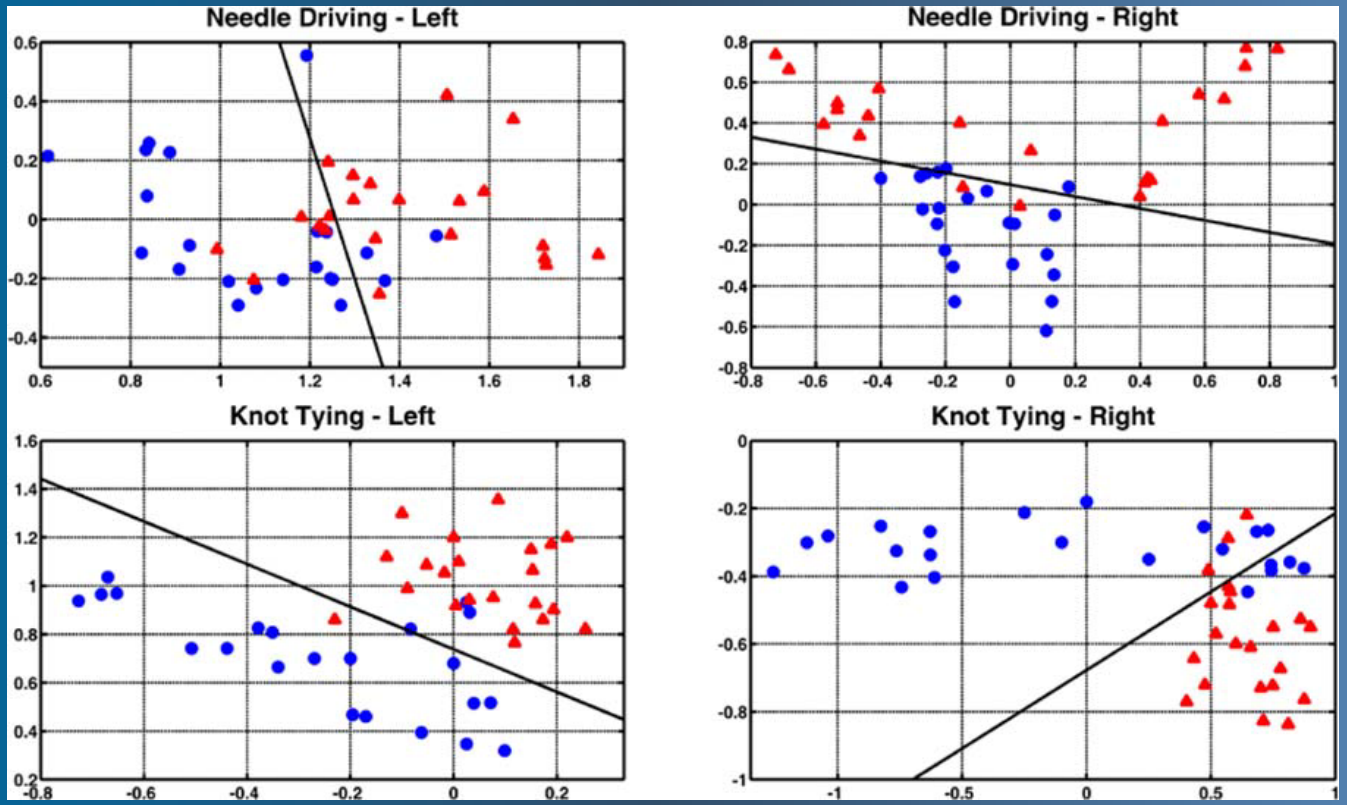


Basic skill-needle driving



Basic skill-knot tying


SAMSUNG



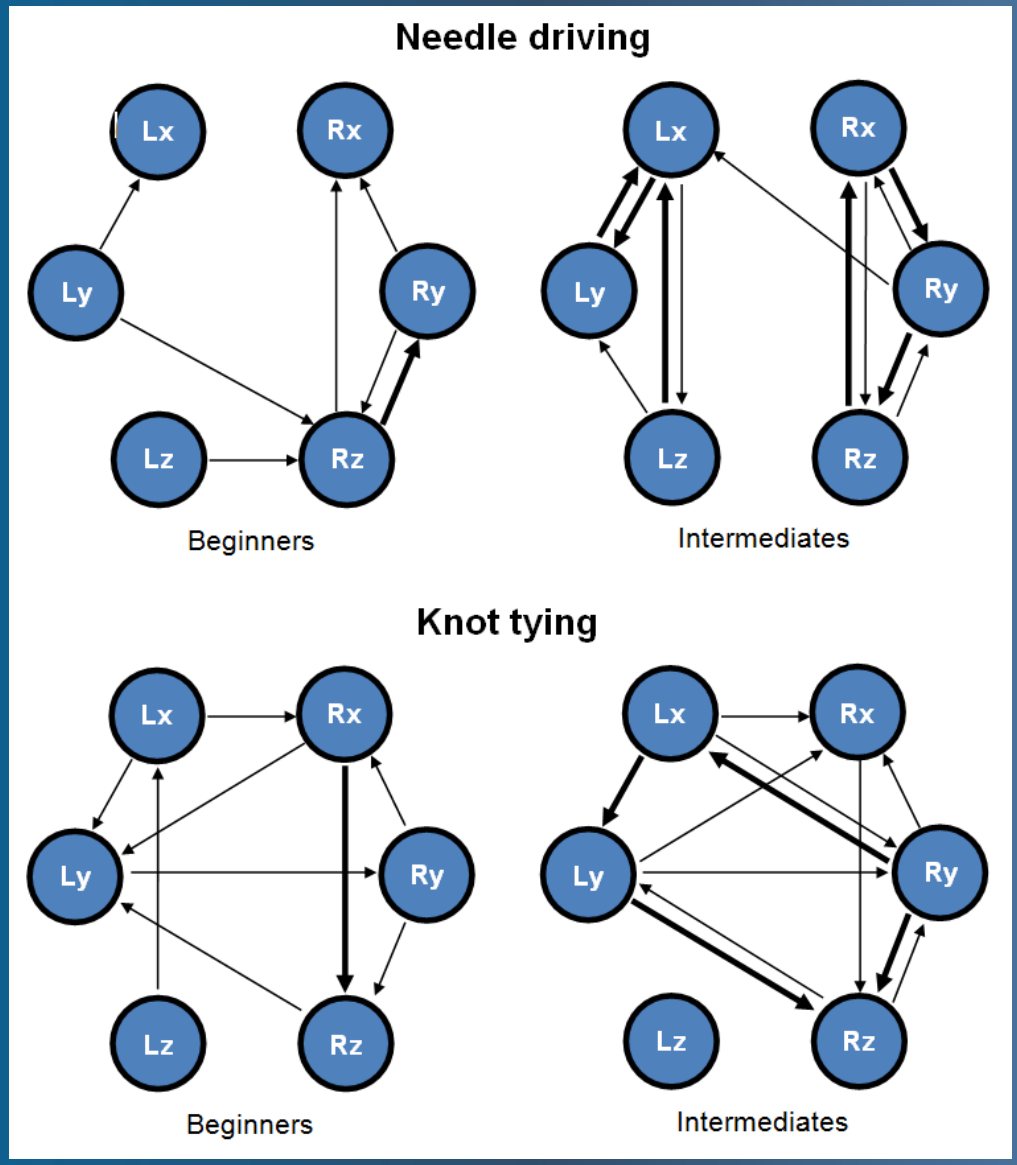
circles/arrows denote intermediates/beginners, respectively.

CLASSIFICATION ACCURACY (% AVERAGE ± SD)

Task	HMM-Left		MAR-Left		HMM-Right		MAR-Right	
	Sen	*Spe*	*Sen*	*Spe*	*Sen*	*Spe*	*Sen*	*Spe*
ND	67 ± 1.7	74 ± 2.1	88 ± 0.9	92 ± 1.8	80 ± 2.6	87 ± 1.8	95 ± 2.7	96 ± 2.4
KT	79 ± 2.6	86 ± 1.9	95 ± 1.4	90 ± 1.6	64 ± 3.2	65 ± 1.9	91 ± 1.7	86 ± 1.4

Sen/Spe: sensitivity/specificity.

Hand motion connection networks

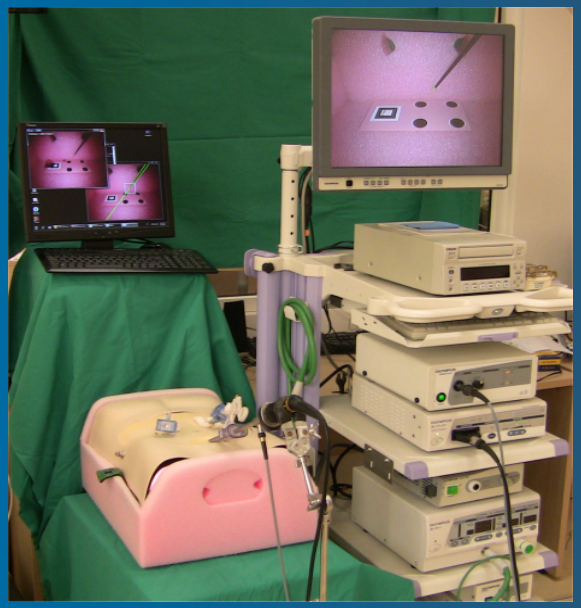


Instrument tracking for AR applications in surgical simulation training

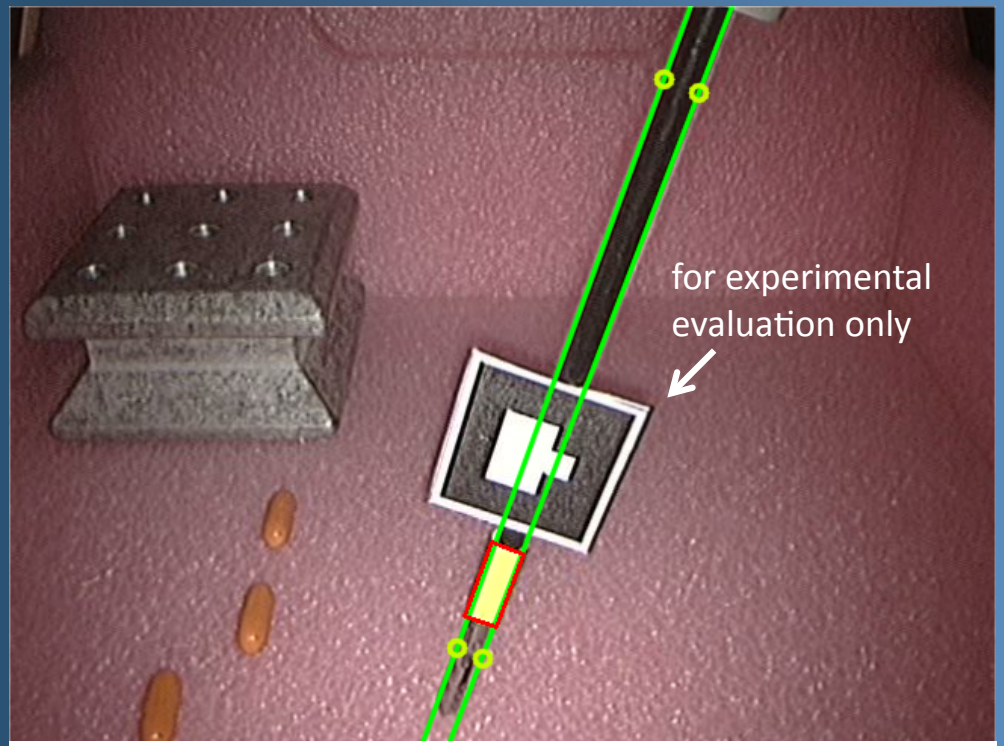
- Despite the popular use of VR and PR simulation, the educational potential of AR has not received much attention.
- Challenge: robust tracking and 3D pose estimation of the instrument. Essential for:
  - achieving interaction with the virtual world and for realistic rendering (occlusion handling).
- We propose a computer vision approach to instrument tracking , position + 3D pose estimation for AR applications.
- Benefits: ultimately users could download the software and practice using their own tools (i.e. without the need of special equipment, sensors, etc.).

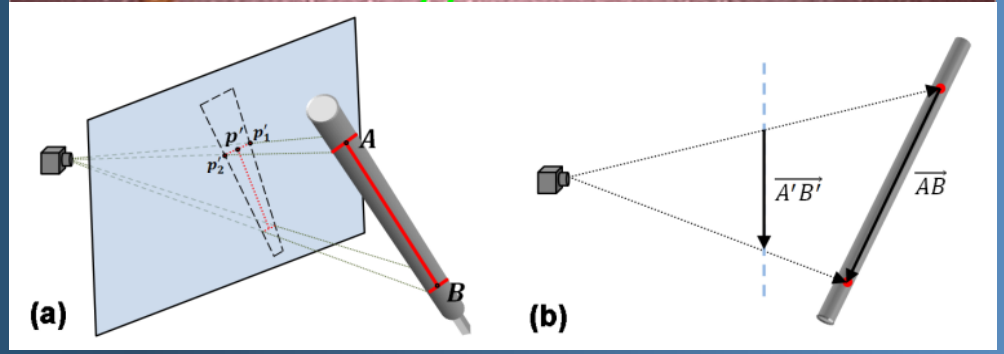
Loukas et al., (in review)

Instrument tracking for AR applications in surgical simulation training

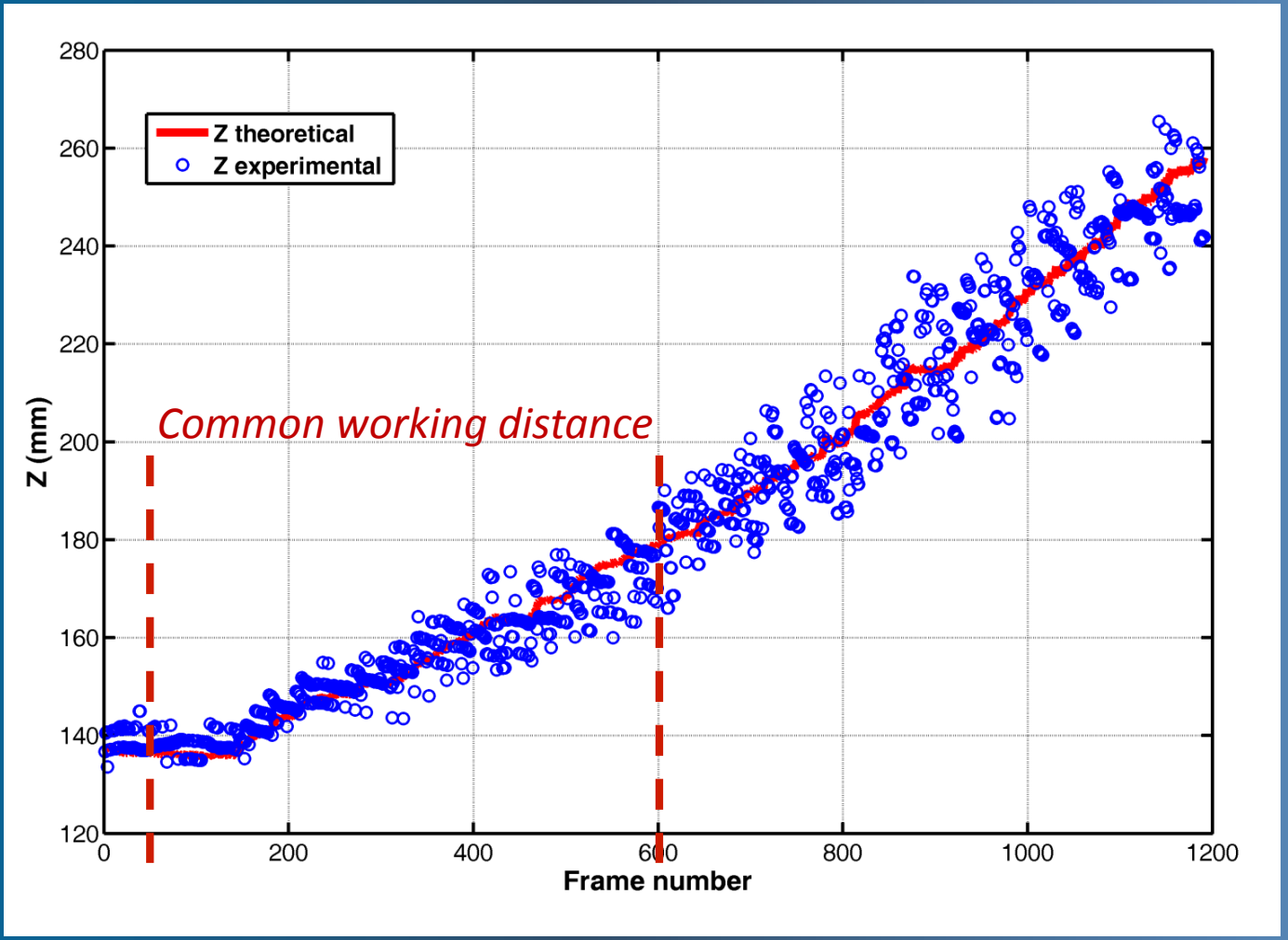


- *camera sensor: 720 × 576*
- *color strip: 6 × 18 mm²*
- *tracking speed: 22Hz*

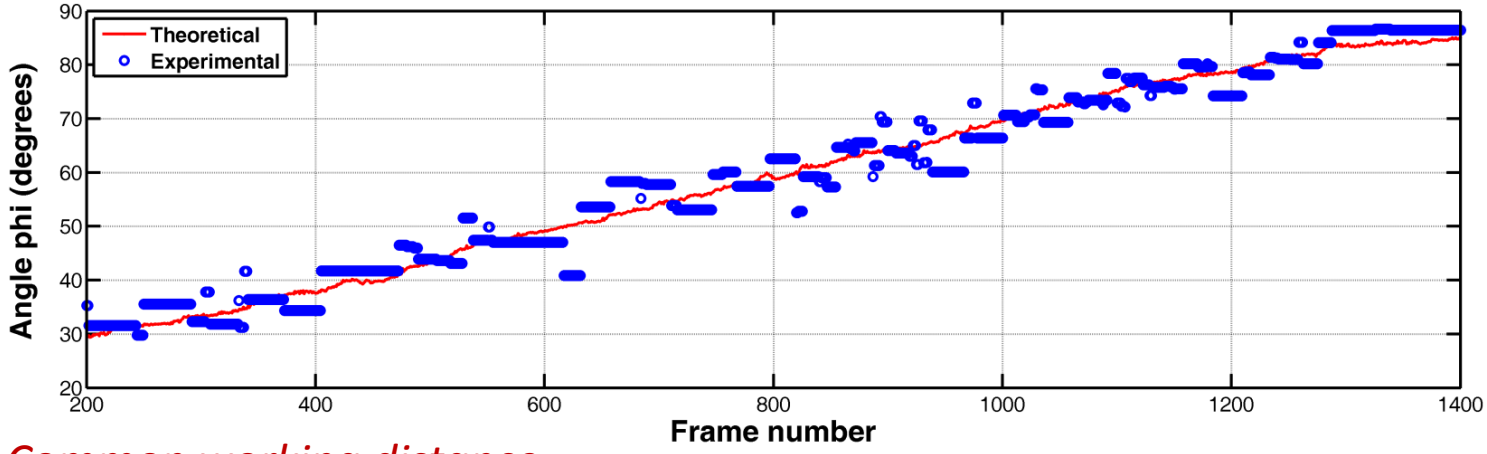




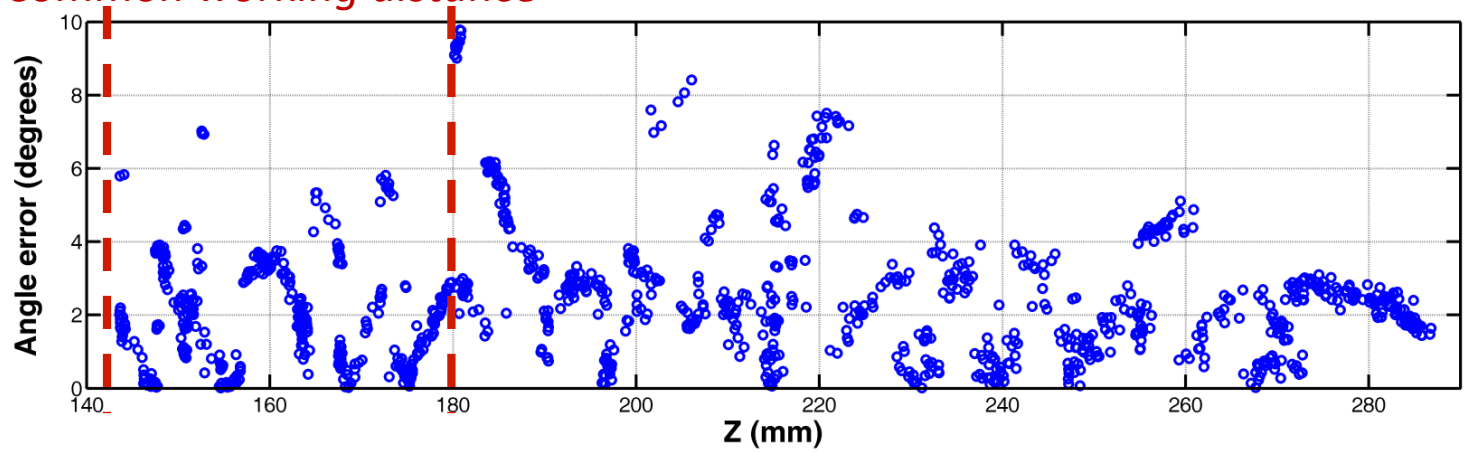
3D tip position accuracy



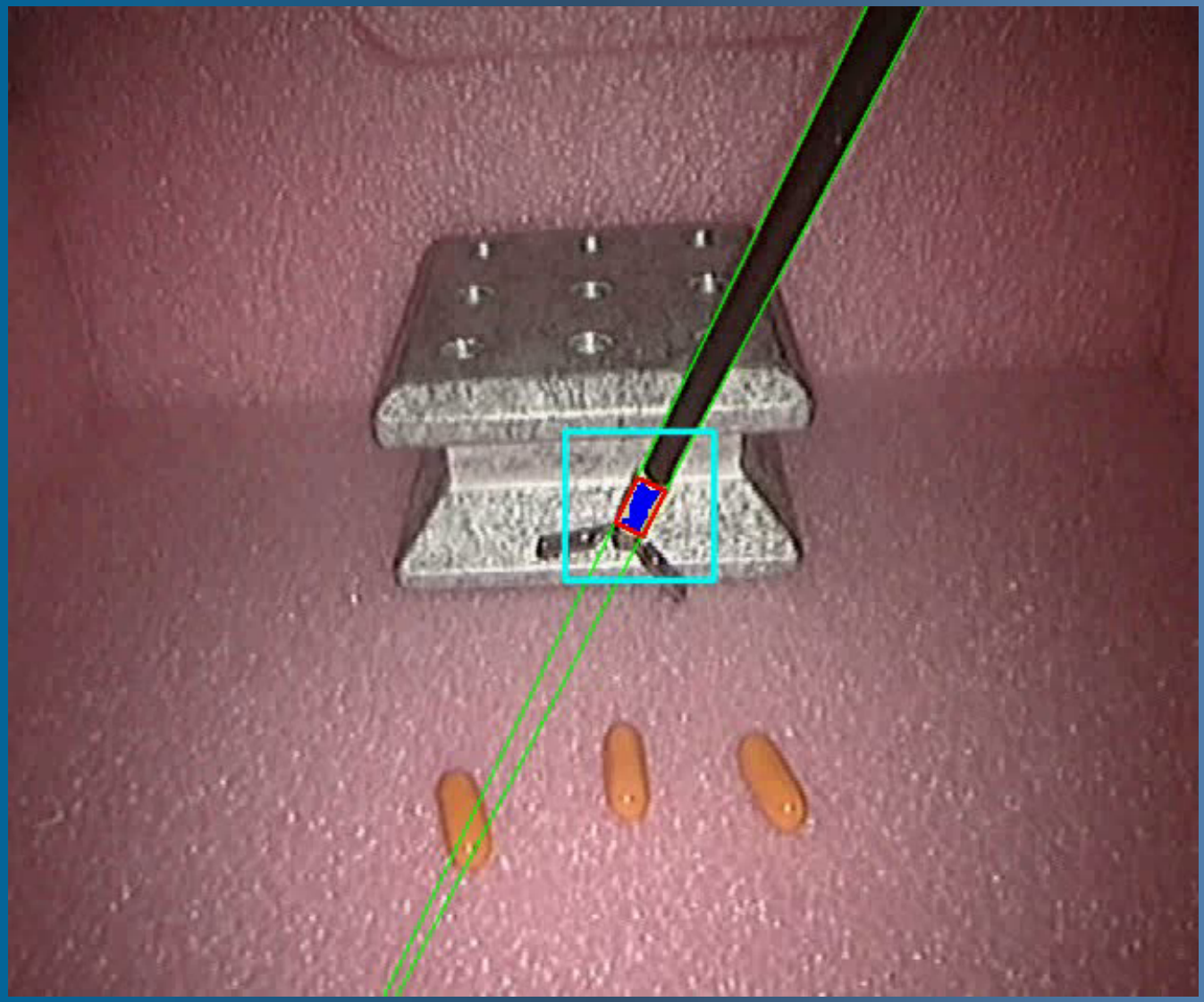
3D instrument pose accuracy



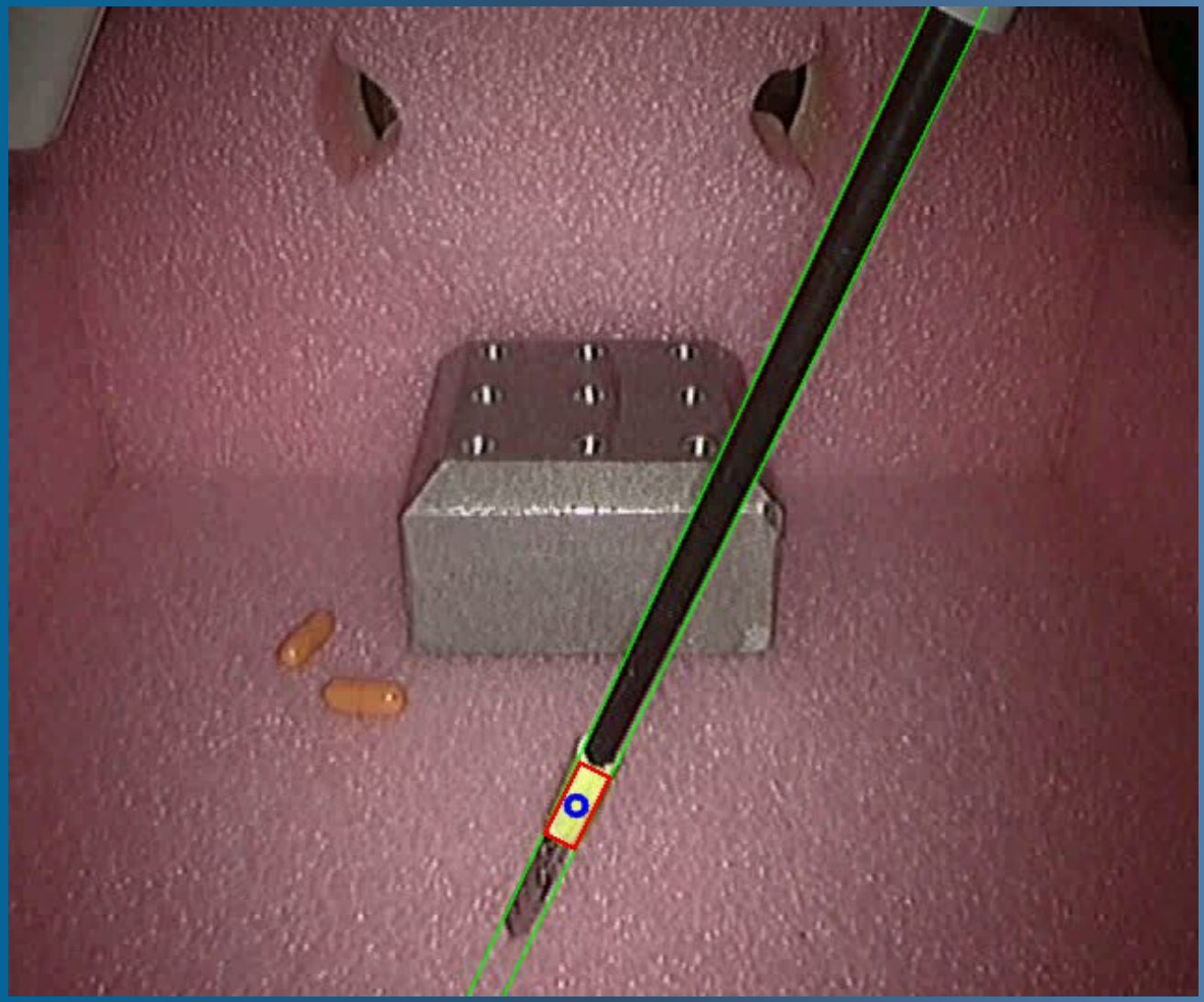
Common working distance



Peg transfer task



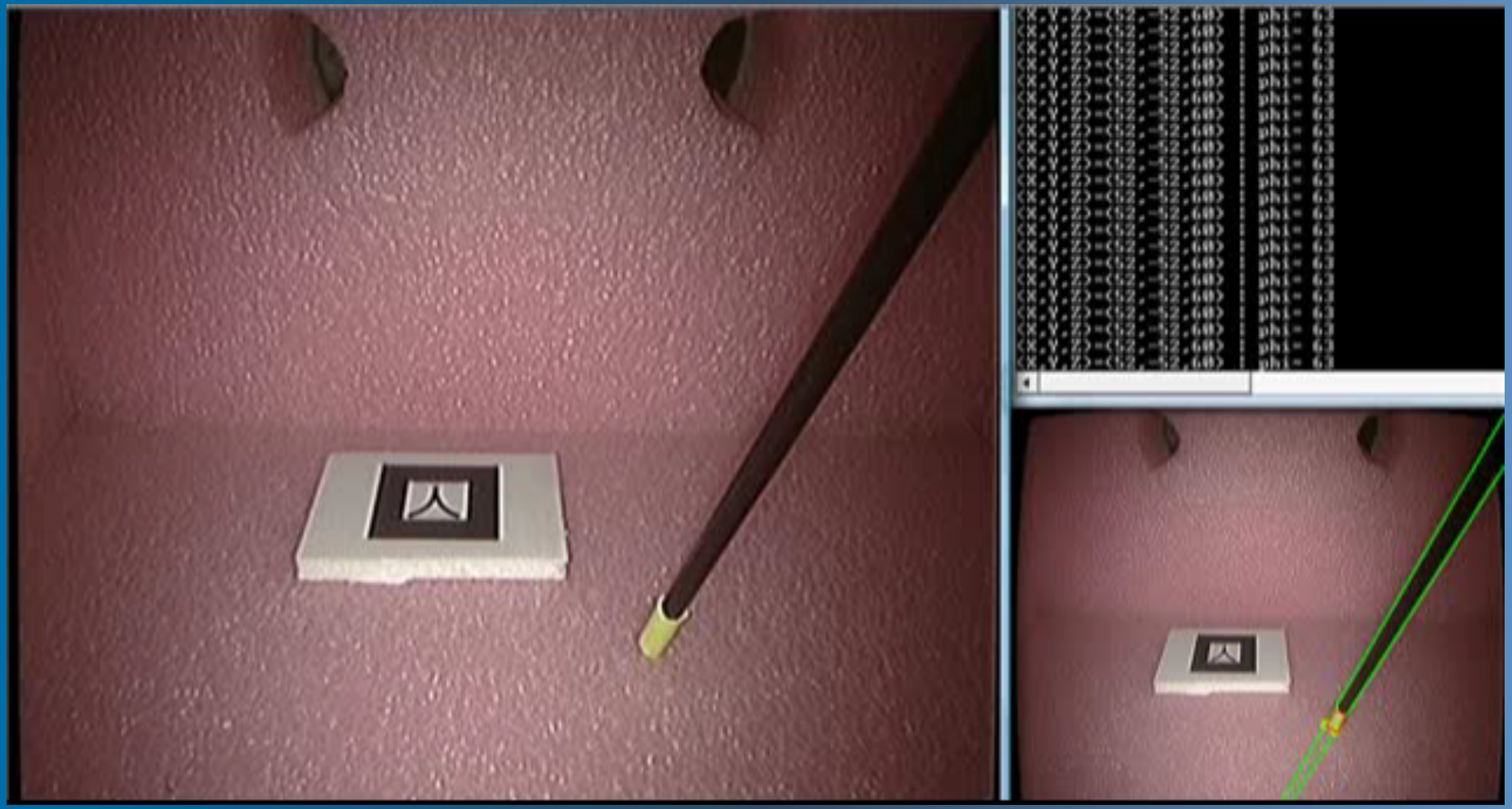
Occluding the color marker (tough!)

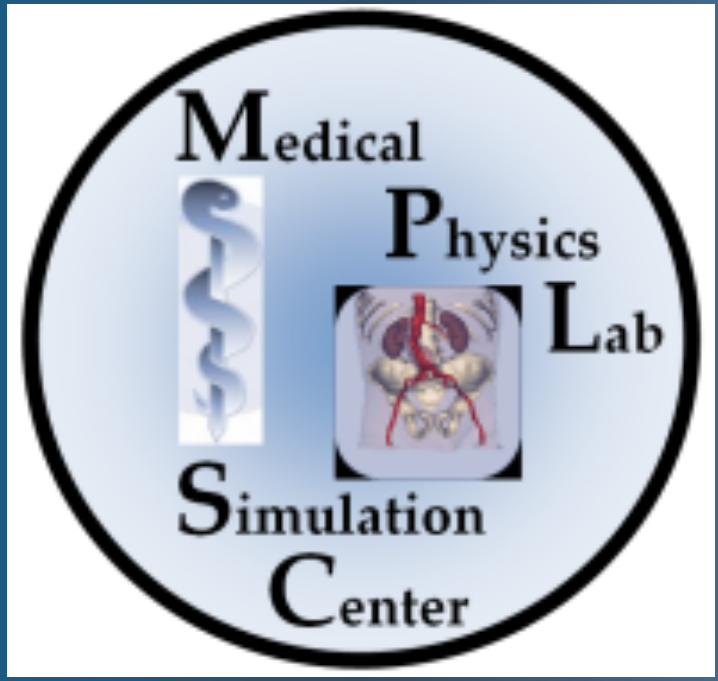


AR simulation training - sphere touching task

AR simulation training - sphere transfer task

AR simulation training - occlusion handling





http://mplsc.med.uoa.gr

Thank you!