Studying the Potential of Virtual Reality Training Platforms for Training Perceptual Motor Skills

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The language of virtual Reality Research

Virtualization: "the process by which a human viewer interprets a patterned sensory impression to be an extended object in an environment other than that in which it physically exists" (p 332).

Presence: "… the sense of being in a VE rather than the place in which the participant's body is actually located… (p 333).

Immersion: "…a person is immersed in an environment that is realized through computer-controlled display systems, and might be able to effect changes in that environment" (p 332).

Sanchez-Vives, & Slater, Nature Review (2005).

Skill acquision and training focus

- **Relevance** of experience
- **Facilitation** of skill acquisition
- **Transfer** of training

Six Demonstrators, Nine Platforms

- Rowing (**ROW**), *Stas Krupenia, Maria Korman*
- Juggling (**JUG**), *Stas Krupenia, Vered Erev*
- Maxillo-Facial Surgery (**MFS**), *Dror Lev, Maria Korman*
- Upper Limb Rehabilitation (**ULR**): (Exoskeleton. Bimanual Trainer) *Danny Gopher*
- Industrial Maintenance and Assembly (**IMA**): (VR, AR) *Nirit Gavis, Geva Vashitz*
- Programming by Demonstration (**PBD**): (VR, AR) *Nirit Gavish, Eldad Yechiam*

Dimensions of engineering novelties

- **Capturing** technologies and methods
- **Rendering** multimodal interfaces, haptics
- **Digital repository**, storage, analysis and modeling

Framework for developing training platforms

- **Skill** is defined as **a well organized knowledge base in long term memory developed with experience and training.**
- This knowledge is best tested by its retention and transfer to recurring or new events.
- Task performance levels by themselves may not be a sufficient indication for learning. They may represent imitation, copying or following instructions.
- Learning requires active interaction and control. It is maximized when it results from intent efforts.

Accelerators and training protocols

- **Training Accelerators (facilitators**) - Variables that are introduced and implemented to facilitate, assist and improve learning.
- **Training protocols** – Training schedule, duration, selected tasks scenarios, difficulty manipulations and their order of presentation

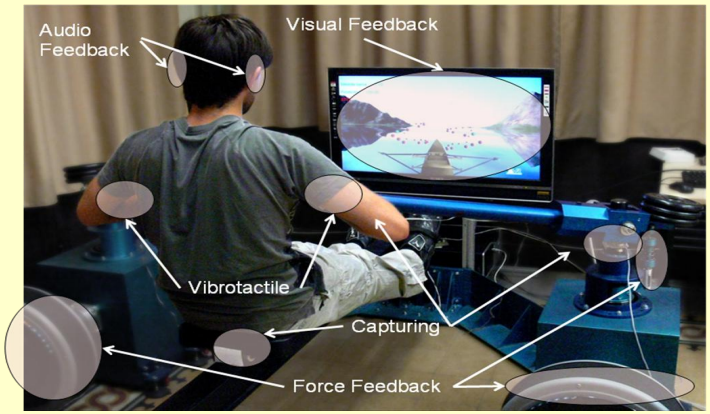
The five composites of a good training protocol

- A clear description of the task and specification of objectives.
- Selection of training scenarios and conditions.
- Defining objective performance criteria and measures.
- Design of feedback (FB) and knowledge of results (KR) indicators.
- Considering the transfer of training from learning to the actual environment.

Rowing

Focus

- **<u>Training Focus</u>:** Acquisition of basic rowing skills (coordinated oar operation), effort and energy management, interpersonal coordination in team rowing.
- **Targeted population**: Novice and Intermediate level rowers



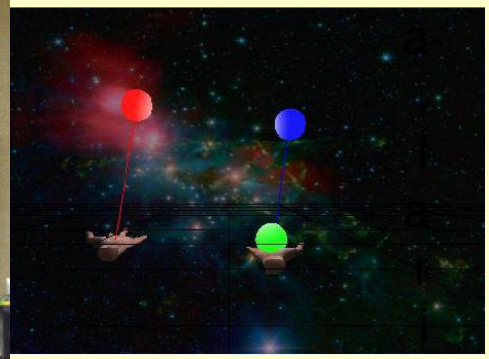
Accelerators

- On line Visual spatial trajectory of rowing pattern **(Fd**).
- On line Vibration directive of rowing pattern **(Fd)**.
- Adjustable auditory pacer of the locomotors/respiratory coupling **(Rhythmic Pacer**)
- A visual director of energy expenditure **(Fd)**
- Visual and haptic information of interpersonal coordination **(Rhythmic Pacer)**

Juggling

Focus

- **Training Focus:** Attention management of multiple moving objects, spatial temporal relationship, bimanual rhythmic coordination.
- **Targeted population**: Novice Jugglers



Accelerators

- Tactile–auditory rhythm trainer of juggling coordination (**Rhythmic Pacer)**
- Training at slow and gradually increasing task speed (**Task processing time)**
- Systematic exploration of the spatial temporal components of the K dwell ratio **(Control strategy**).

Maxillo Facial – Jaw surgery

Focus

- **Training Focus**:
  Drill and tool operation. Fine control of force application, use of fine graded touch and visual information.
- **Targeted population**: Trained surgeons

Accelerators

- Feedback on forces and torques applied to the tool **(Fd**)
- Visual feedback on performance from an "impossible" anatomical point of view **(Fd**)
- Performance feedback relative to optimal performance lines (**Fd)**
- Multimodal feedback to enhance sensitivity to compliance and vibration change **(Fd**)

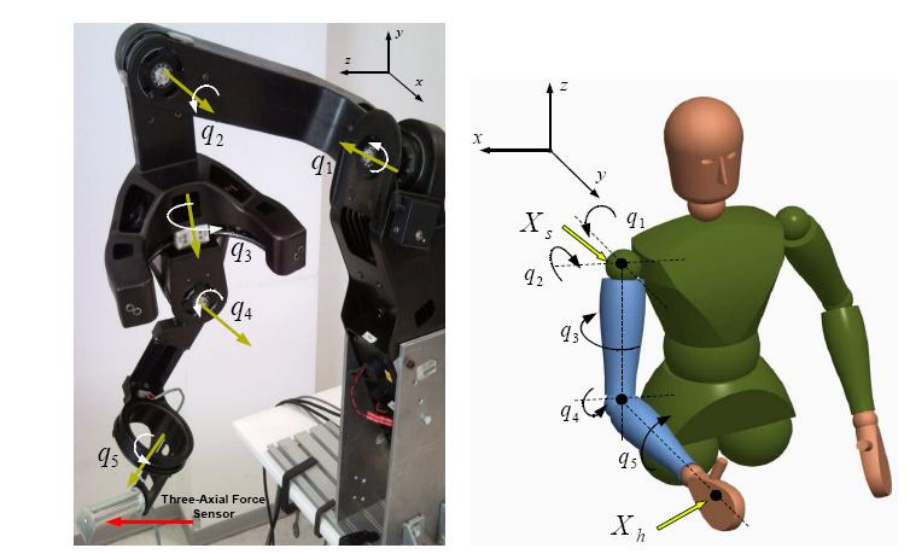
Upper Limb Rehab.

Focus

- **Training Focus**: using robotic technology and VR environment to expend therapeutic options and interaction with patients in upper limb rehabilitation
- **Targeted population**: patients undergoing limb control physiotherapy.
- **Two platforms**: Exoskeleton. Bimanual

Accelerators

- Task selection, game like computer tasks.
- On line continuous feedback (**FD)**
- Movement assistance **(FD, Motivation)**



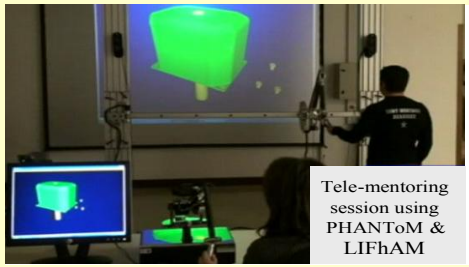
IMA – Industrial Maintenance

Focus

- **Training Focus**: Acquisition of procedural skills in a virtual environment and via a remote augmented reality training
- **Targeted population**: Technicians and machine operators.
- **Two platforms**: AR, VR

Accelerators

- Including haptic in 3D VR training **(Hp Enact)**
- Adding abstract representation (**Cog. Aid**)
- Introducing direct visual aid (pointer) (**Vis. Director)**
- Adding images of parts (**Cog. Aid)**
- Adding rotational haptic hints **(Hp Enaction)**
- Augmenting enaction by theoretical instructions **(Cog. Aid**)



Tele-mentoring session using PHANToM & LIFhAM

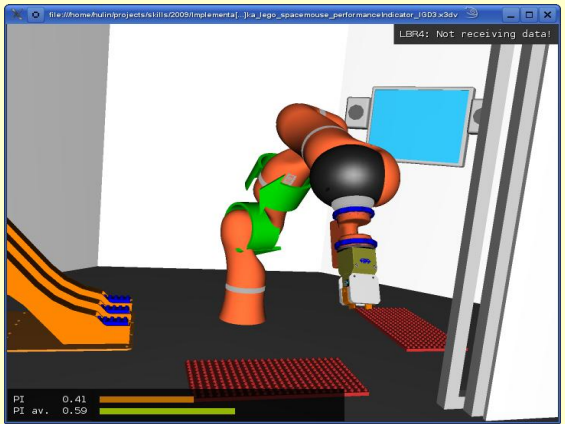
Programming By Demonstration

Focus

- **Training Focus**: Exploring and adapting behavior to the motion and Compliance constraints of a robotic arm
- **Targeted population**: PBD robot operators
- **Two platforms**: AR, VR

Accelerators

- On line indicators of approaching singularity (**Fd)**
- Voluntary exploration of singularity (**Control strategy**).
- Haptic exploration of compliance parameters setting (**Hp. Enaction**)



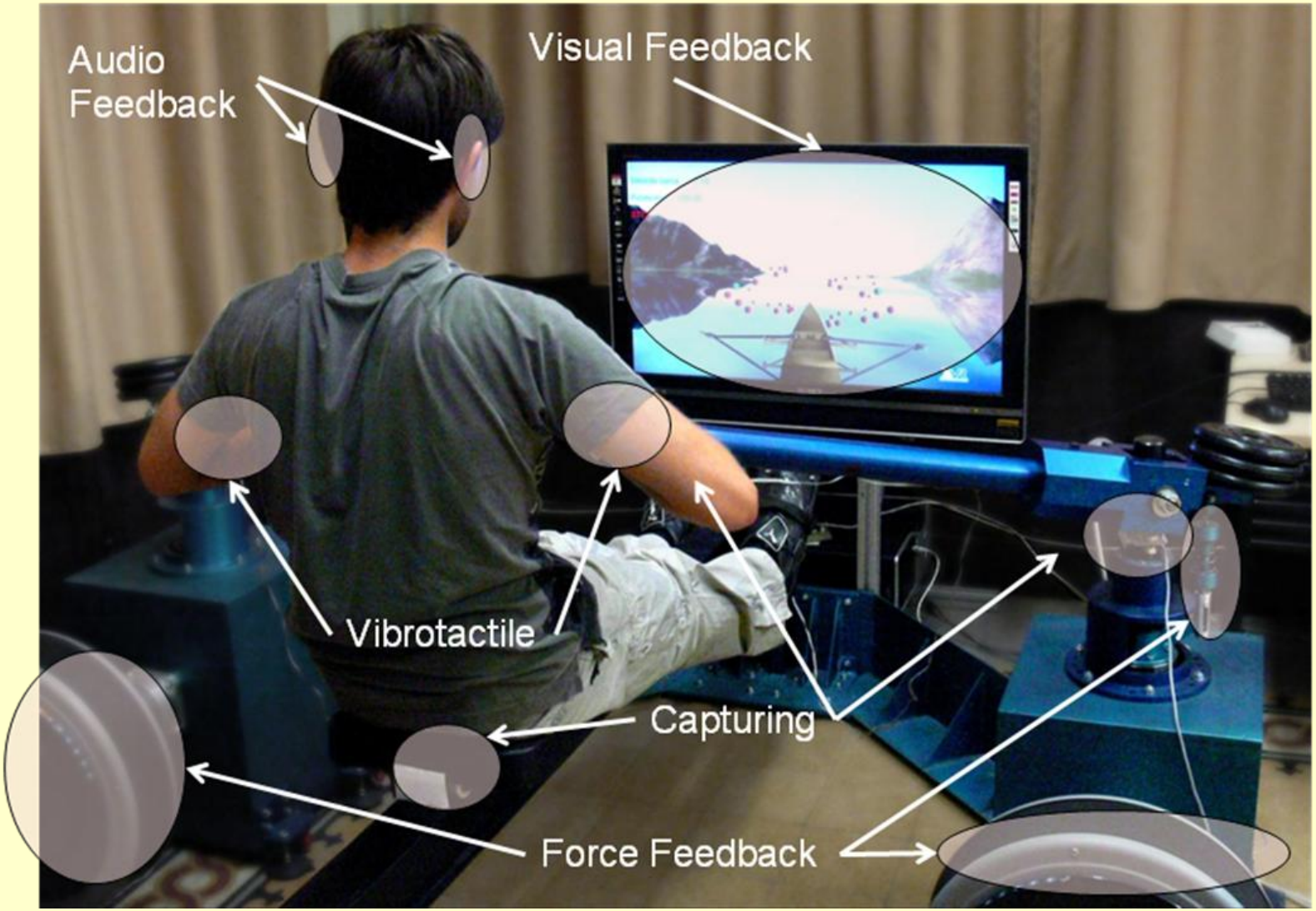
Classes of Accelerators

- **Augmented Feedback** – Augmented information of own performance (respiration- ROW, force application, MFS)
- **Augmented KR** – Performance in reference to a external model (Expert rower ROW, approaching singularity PBD, rhythmic pacers, Jug, Row)
- **Multimodal experience and feedback** - Emphasis on haptic and on order of adding modality information (MFS, IMA, ROW)..
- **Augmented and changed reality**; speed manipulation, JUG, vision from impossible angles, MFS tools torque MFS, abstract and direct visual aid IMA , robotic assistance ULR. AVATAR team member ROW
- **Cognitive control strategies** (dwell ratio JUG, exploring the motion space PBD)
- **Situation and task selection** (tasks and games ULR)

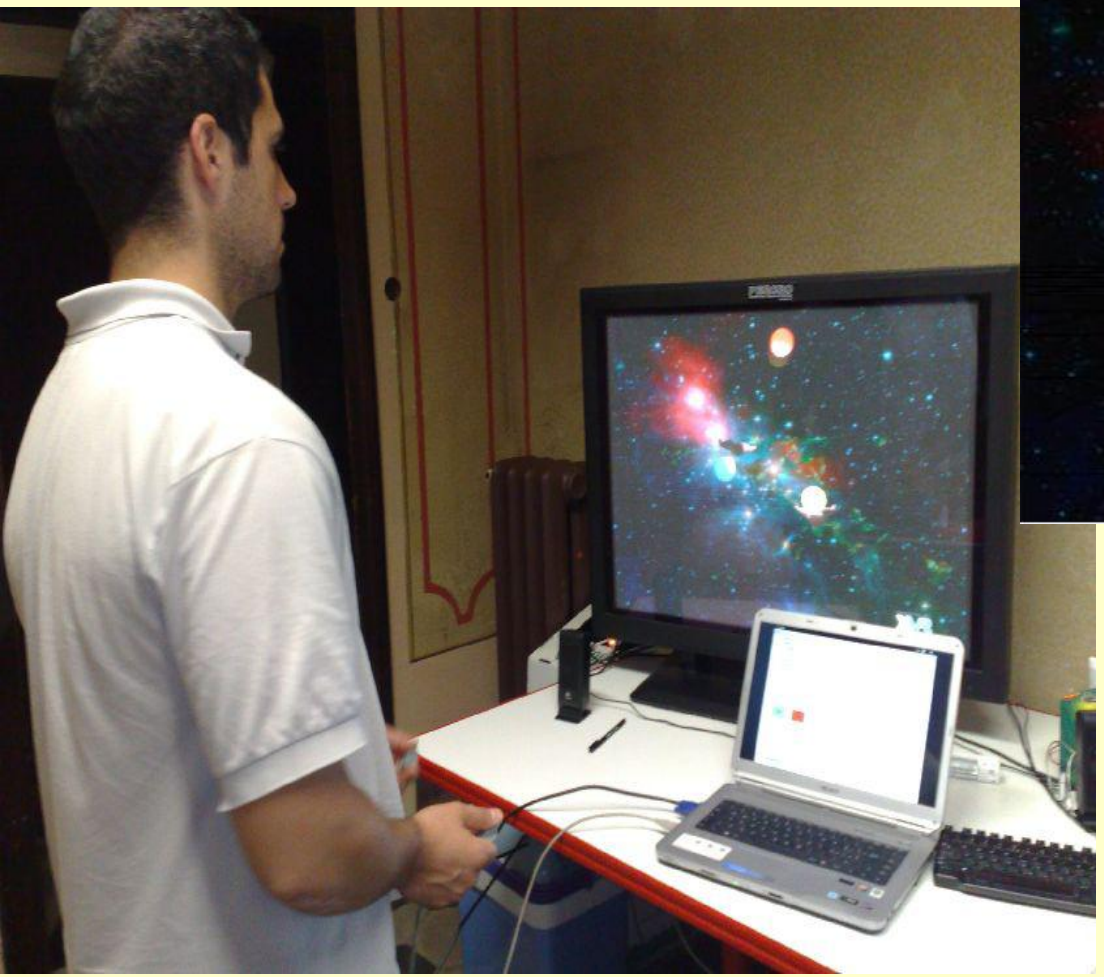
Evaluation of the VR training platforms

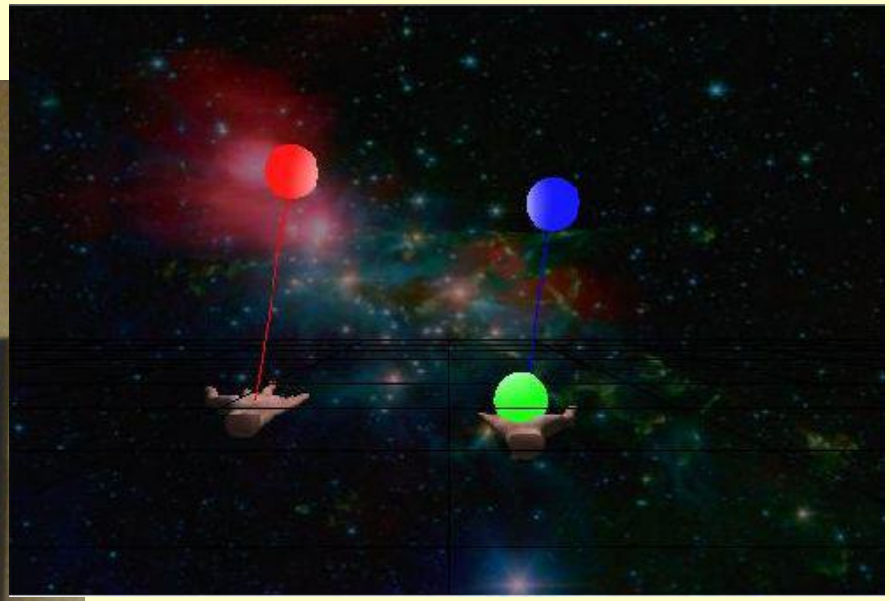
- Evaluation and modeling of the differential experience of performing the same tasks on the VR platform and in the real world.
- Evaluation of the contribution of accelerators.
- Assessment of training protocols that will maximize learning and skill acquisition on a platform.
- Transfer of training studies.

Rowing


Audio
Feedback
Visual Feedback
Vibrotactile
Capturing
Force Feedback

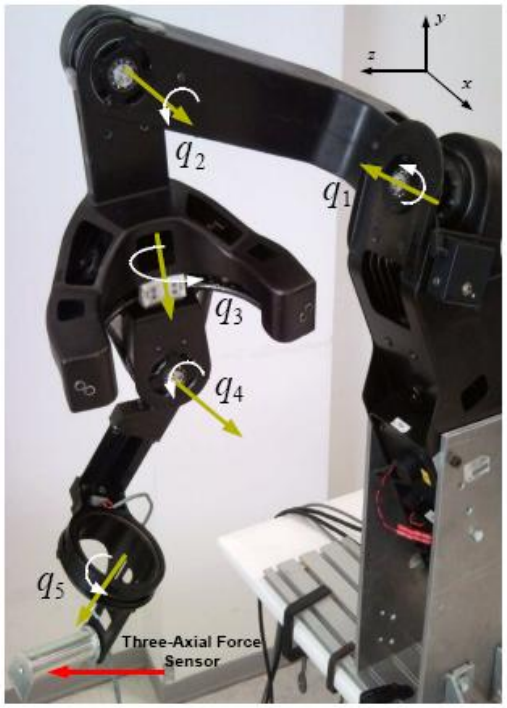
Juggling

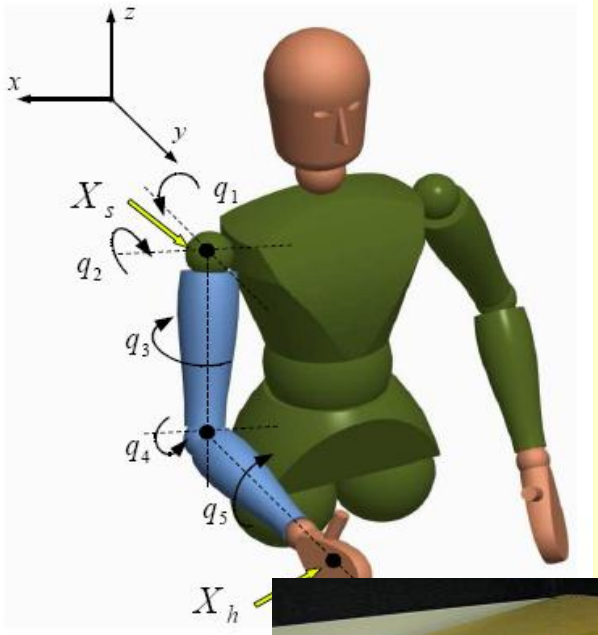




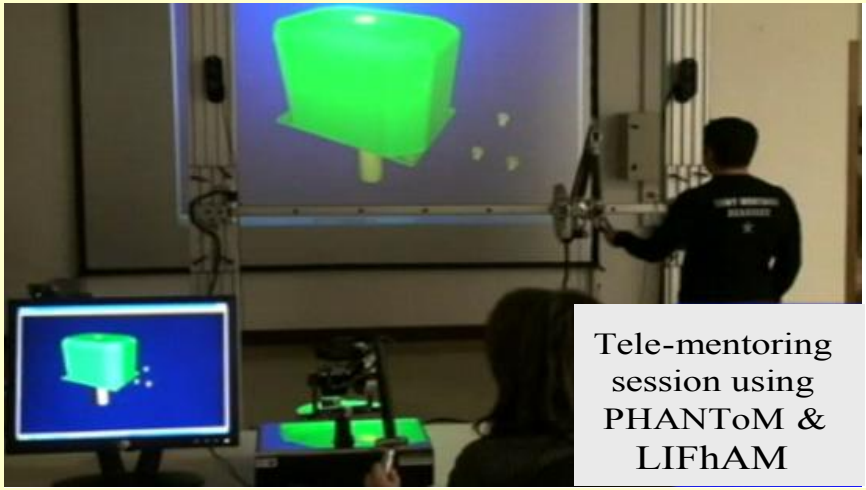
Maxillo Facial – Jaw surgery

Upper Limb Rehabilitation



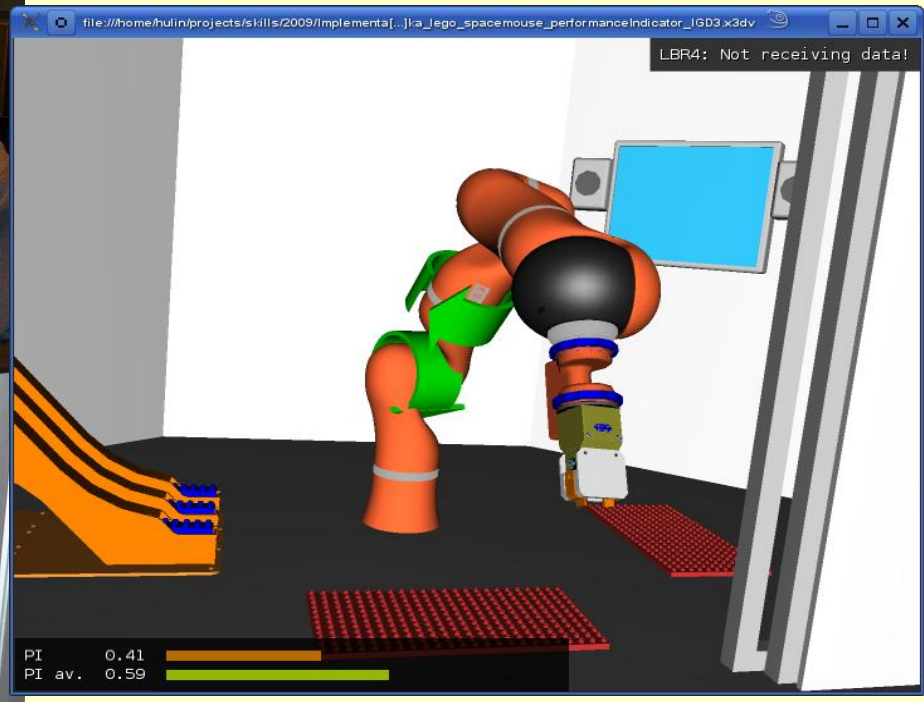


Industrial Maintenance and Assembly



Tele-mentoring session using PHANToM & LIFhAM

Programming by demonstration



Task and objectives specification

- Task to be learned.
- Skills and competencies to be acquired,
- Objectives of training
- Designation of criteria for graduation

Training scenarios and conditions

Richer, diversified and representative training environment leads to the development of a more flexible, generalizable and higher level competences:

- 1. Design of representative task scenarios and task versions.
- 2. Selection of task difficulty manipulations that best represent typical encounters and key requirements of the task.
- 3. Plan their order and combinations of presentation.

Performance Criteria and Measures

- Identification of key response and performance measures.
- Definitions of progress criteria on relevant aspects of task performance and enhanced competence.

Feedback (FB) and Knowledge of Results (KR)

- Type of FB and KR information.
- Modality of FB and KR.
- Frequency, schedule and resolution of FB and KR.
- On line off line FB and KR.

Transfer of training

- Relevance of the part task training experience to the performance of the actual task. (Distinguishing between performance on trainer and transfer).
- Beware of illusionary conjunctions (validity of VR experience. Low validity may result in negative transfer).
- Major considerations: At what stage to introduce training? How to plan the move from the trainer to actual task performance?