Developing Virtual Reality Environments for Skill Training and Rehabilitation

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15 Project Participants
9 European Countries

Academic Institutions
- SSSA (Coord.)
- Queen’s Univ.
- Technion
- Univ. of Montpellier
- Aalborg Univ.
- Univ. Tampere

RTD Centers
- Fraunhofer IGD
- DLR
- LABEIN
- CEA
- CEIT

Enterprises
- KUKA
- Simonazzi (TetraPack)
- Haption
- OMG (VICON)
Virtual Multimodal Simulations

• Development of sensor and display technologies led the way to the development of multimodal virtual worlds.
• Performers are immersed, experience multimodal sensations and interacts with virtual objects including other humans.
• Haptics is the newest important addition to vision and audition. The ability to feel and exercise force, touch, texture and kinematic
• Ample research show the benefits of multimodal experience and encation to learning and skill acquisition
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).

Skill acquisition and training focus

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

Different challenges, research questions and engineering requirements
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.
The five composites of a good training protocol

• A clear description of the task to be learned and specification of learning 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.
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
Dimensions of engineering novelties

• **Skill Capturing** technologies and methods
• **Rendering** multimodal interfaces, haptics
• **Digital repository**, storage, analysis and modeling
Six Demonstrators, Nine Platforms

- Rowing (ROW),
- Juggling (JUG),
- Maxillo-Facial Surgery (MFS),
- Upper Limb Rehabilitation (ULR): (Exoskeleton. Bimanual Trainer)
- Industrial Maintenance and Assembly (IMA): (VR, AR)
- Programming by Demonstration (PBD): (VR, AR)
Maxillo Facial – Jaw surgery

Focus

• Training Focus:
  Drill and tool operation. Fine control of force application, use of fine graded touch and visual information to detect the Spix of spine.

• Targeted population: Trained surgeons

Accelerators

• Feedback on forces and torques applied to the tool \( (F_d) \)
• Visual feedback on performance from an “impossible” anatomical point of view \( (F_d) \)
• Performance feedback relative to optimal performance lines \( (F_d) \)
• Multimodal feedback to enhance sensitivity to compliance and vibration change \( (F_d) \)
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)
Classes of Accelerators

• Multimodal enriched experience - Emphasis on haptic and on order of adding modality information

• Augmented Feedback – Augmented information of own performance (effort, respiration- ROW)

• Augmented KR – Performance in reference to a external model (Expert rower ROW, rhythmic pacers, J ug, Row)

• Augmented and changed reality; speed manipulation, J UG, vision from impossible angles, AVATAR team member ROW

• Cognitive control strategies (dwell ratio J UG)

• Situation and task selection
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.
Maxillo Facial – Jaw surgery
Upper Limb Rehabilitation
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.
Task and objectives specification

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