3D Interaction with Virtual Environments based on Body and Brain

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Introduction

Anatole Lécuyer
• Inria Senior Researcher

Hybrid team
• Location: Rennes
• Group: ~20 people (12 PhD students)
• Affiliation: Inria/IRISA

Scientific field: Virtual Reality & 3D interaction with Virtual Environments
Virtual Reality (VR)

**Definition:** “a virtual reality system is an immersive system that provides the user with a feeling of presence (the feeling of "being there" in the virtual world) by means of plausible interactions with a synthetic 3D environment simulated in real-time” (Lécuyer, 2010)

**Examples of VR interfaces (Input/Output)**

- **Visual displays**: stereoscopic 3D display (Output)
- **Haptic interfaces**: force/tactile feedback (Input/Output)
- **Locomotion interfaces**: navigation (Input/Output)
- **Brain-Computer Interfaces**: control with brain (Input)
Virtual Reality Technologies
Challenges and Applications

Challenges

1. Modeling and simulation of complex 3D scenes
2. Interaction paradigms adapted to 3D
3. Sensory feedbacks and rendering algorithms

Applications

Industry, Medicine, Arts, Entertainment, Design
Research objectives

>> Improve 3D interaction with virtual environments
   Making full use of available interfaces and sensory modalities:
   “Using eyes, hands, feet and brain” >> body and brain

Open questions

- 3D simulation: more realistic
- 3D interaction technique: more effective
- Sensory feedback: more immersive

Perception-based approach

- Use knowledge in perception and neuroscience for Design/Evaluation
- Collaborations: INSERM (O. Bertrand, JP. Lachaux, J. Mattout), Collège de France (A. Berthoz), Univ. Pierre Mendès-France (E. Gentaz), Fribourg Univ. (J. Wiener), etc
Research results

Visual Interfaces  
Haptic Interfaces  
Locomotion Interfaces  
Brain-Computer Interfaces
Research results

- **Visual Interfaces**
- **Haptic Interfaces**
- **Locomotion Interfaces**
- **Brain-Computer Interfaces**

>> **Perception-based** design of VR systems
Research results

Visual Interfaces
Haptic Interfaces
Locomotion Interfaces
Brain-Computer Interfaces
Gaze-tracking and visual attention models

(Hillaire et al., IEEE TVCG 2012)

(Hillaire et al., Computer Graphics Forum 2010)
Automatic adaptation of visual rendering based on user’s gaze

(Hillaire et al., IEEE VR 2008)
FlyVIZ  (Ardouin et al., ACM VRST 2012)
Research results

Visual Interfaces

Haptic Interfaces

Walking Interfaces

Brain-Computer Interfaces
Haptic Rendering (physically-based)

Haptic interaction with fluids
(Cirio et al., IEEE TVCG 2012)
(Cirio et al., IEEE ToH 2013)

Multi-state haptic interaction
(Cirio et al., IEEE VR 2011)
Pseudo-Haptic Feedback (perception-based)

Objective: provide haptic sensations using visual feedback

Example: feel the texture of 2D images with a mouse cursor

(Lécuyer et al., ACM CHI 2004)
(Lécuyer et al., ACM TAP 2010)
(Argelaguet et al., Eurohaptics 2012)

on-line demos:
http://www.irisa.fr/tactiles/
http://team.inria.fr/hybrid
State-of-the-Art in Pseudo-Haptics (00-15)

Fundamental studies:
- Friction *(IEEE VR 2001)*
- Stiffness *(IEEE VR 2001)*
- Mass *(IEEE VR 2005)*
- Textures *(Eurohaptics 2010)*
- Avatars *(IEEE VR 2014)*

Applied studies:
- Vocational training *(IEEE VR 2005)*
- Medicine *(ACM VRST 2008)*
- Showcasing and interactive kiosks *(IEEE 3DUl 2013)*
- Web (W3D project)

In brief: ~25 papers, 1 survey *(Presence 2009)*

Active field: +30 labs (Univ. of Tokyo, EPFL, UBC, etc)
Haptic motion (vection illusion) *(Ouarti et al., WHC 2013)*
Motion effects in movies *(Danieau et al., Haptics 2012)*
HapSeat *(Danieau et al., ACM VRST 2012)*
Haptic cinematography *(Danieau et al., IEEE Multimedia 2013)*
Research results

Visual Interfaces

Haptic Interfaces

Walking Interfaces

Brain-Computer Interfaces

natural interactive walking
« Joyman » : Human-Scale Joystick

Navigation interface based on equilibrioception

(Marchal et al., IEEE 3DUI 2011)
(Pettré et al., SIGGRAPH Asia E-tech 2011)
Patent (Pettré et al., 2011)
Camera motions

Objective: improve sensation of walking

Different studies:

- Novel models of camera motions
  (Lécuyer et al., IEEE VR 2006)
- Use of an eye-tracking system
  (Hillaire et al., IEEE VR 2008)
- Perception of traveled distances
  (Terziman et al., IEEE VR 2009)
- Multi-state and personified CM
  (Terziman et al., IEEE VR 2013)
Research results

- Visual Interfaces
- Haptic Interfaces
- Walking Interfaces
- Brain-Computer Interfaces
Brain-Computer Interfaces and VR

Brain-Computer Interfaces (BCI)
Interaction using mental activity (EEG)
Mental tasks: motor imagery, attention, etc

BCI and Virtual Reality?
BCI for VR: novel input
VR for BCI: learning/motivation

Problem
small number of reliable commands

Challenges
(1) Neuroscience knowledge
(2) EEG and “mental sensors”
(3) Signal processing techniques
(4) Interaction paradigms
(5) Transfer to patients
OpenViBE project (2005-2009)

BCI for disabled people / open-source software

www.irisa.fr/vr4i/OpenViBE/wiki
OpenViBE software

Standard tool for BCI research
Free and open-source
Worldwide success (30K downloads)
Inria support (>2009)


http://openvibe.inria.fr
OpenViBE2 project (2009-2013)

from “casual” to “serious” videogames
HEMISFER project (2013-2016)

Neurofeedback based on fMRI & EEG, and VR

Partners:

• **Inria**
  Dr Anatole LECUYER
  Dr Christian BARILLOT
  Dr Rémi GRIBONVAL

• **CHU Rennes (reeducation)**
  Pr Isabelle BONAN

• **CHGR Rennes (psychiatry)**
  Pr Bruno MILLET
  Pr Dominique DRAPIER

Pathologies:

• Motor deficiencies
• Psychiatric disorders
Startup : Mensia Technologies

Inria start-up company (Nov. 2012)
Medical applications (Neurofeedback)
Location: Rennes (Inria), Paris (ICM)
Contact:
  • Jean-Yves Quentel (CEO)
  • Yann Renard (CTO)

>> http://www.mensiatech.com/
Recent results on BCI ?
Hybrid Interaction (BCI and Mouse)

J. Mercier-Ganady, E. Loup-Escandey, L. George, C. Busson, M. Marchal, A. Lécuyer, “Can We Use a Brain-Computer Interface and Manipulate a Mouse at the Same Time?”, ACM Symposium on Virtual Reality Software and Technology (ACM VRST), Singapore, 2013
Multi-User BCI

Video 1 : Competition

Video 2 : Collaboration

L. Bonnet, F. Lotte, A. Lécuyer, "Two Brains, One Game: Design and Evaluation of a Multi-User BCI Video Game Based on Motor Imagery", IEEE Transactions on Computational Intelligence and AI in Games, 2013
Adaptive Medical Simulator (Passive BCI)

Video


Mind-Mirror (Augmented Reality and BCI)

Video

Immersive Virtual Reality and BCI

Video

Conclusion

✓ Virtual Reality : well-established scientific field
✓ Numerous applications : medicine, industry, arts, entertainment, etc
✓ Numerous questions/challenges : hw, sw, physical simulation, 3D interactive techniques, perception, application transfer, etc
✓ Perception-based approach : design/simplification of VR systems (-illusions and pseudo-haptics)

Follow-us?  >> [http://team.inria.fr/hybrid](http://team.inria.fr/hybrid)
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Thank you!

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