3D Interaction with Virtual Environments based on Body and Brain

Anatole Lécuyer (Inria)

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Introduction

http://team.inria.fr/hybrid

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***

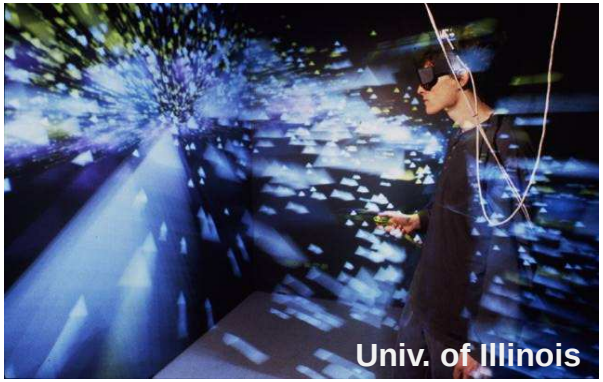
Hybrid

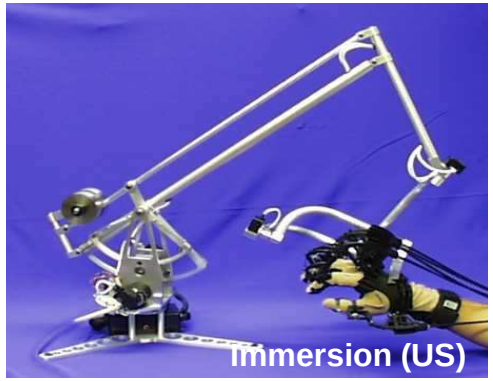
Virtual Reality (VR)

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**)

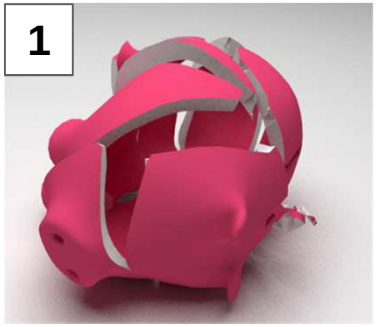




Virtual Reality Technologies

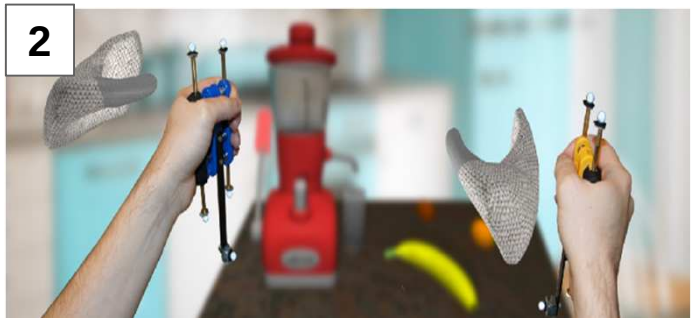
Immersia, Inria/IRISA Rennes

Challenges and Applications



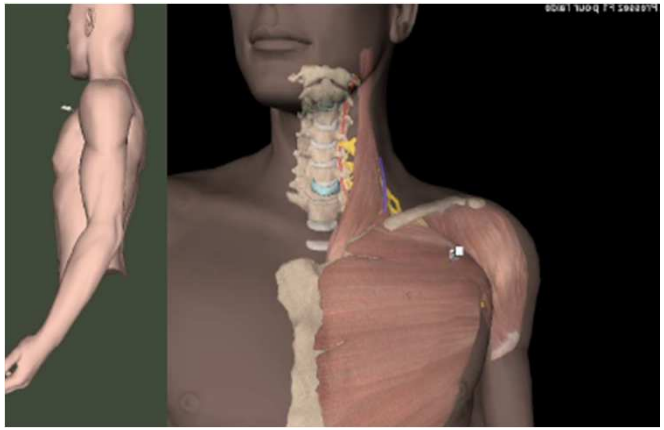
Challenges

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

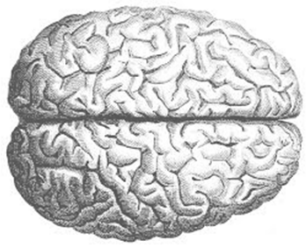
Open questions

- 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

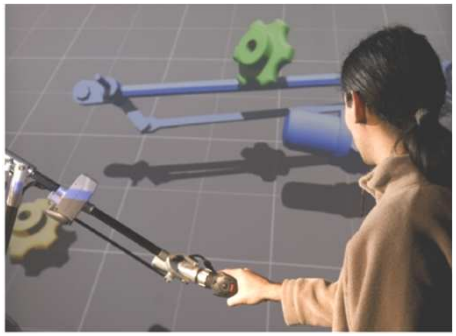


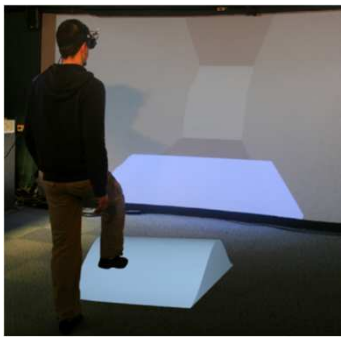
Research results

Visual Interfaces

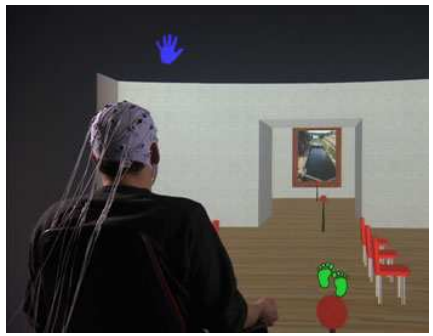
Haptic Interfaces

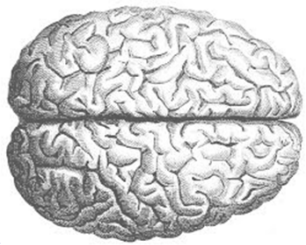


Locomotion Interfaces



Brain-Computer Interfaces





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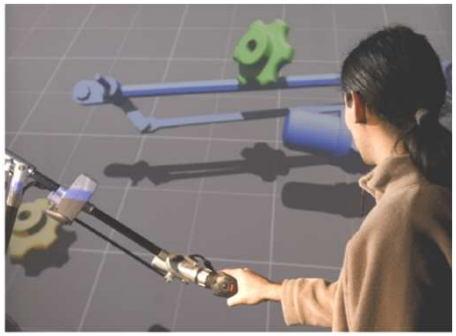
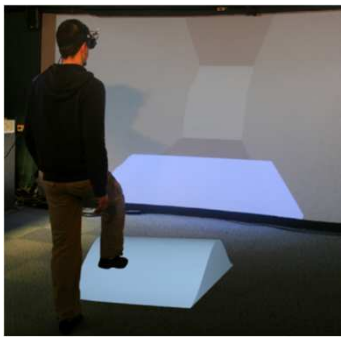


Locomotion Interfaces



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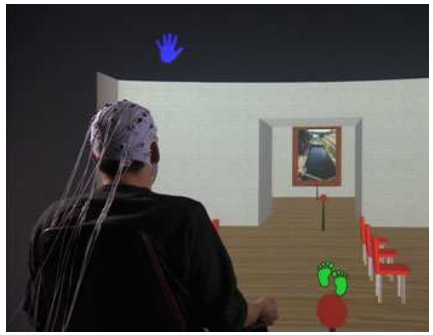
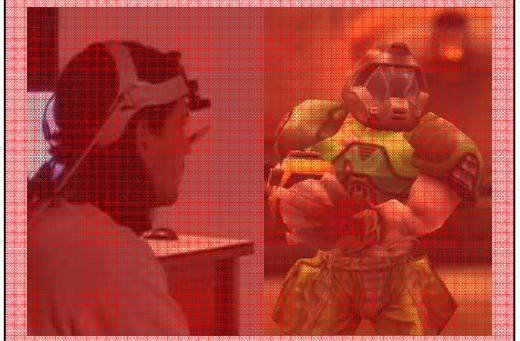


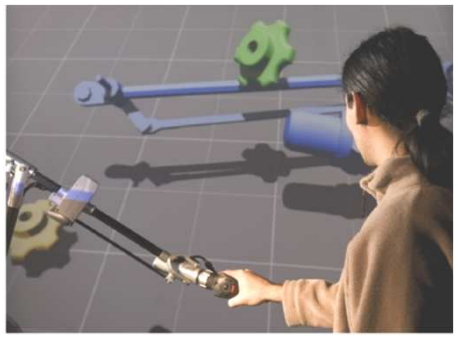
>> Perception-based design of VR systems

Research results

Visual Interfaces



Haptic Interfaces



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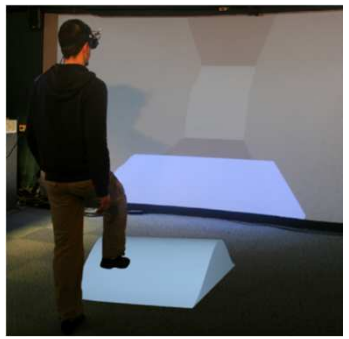

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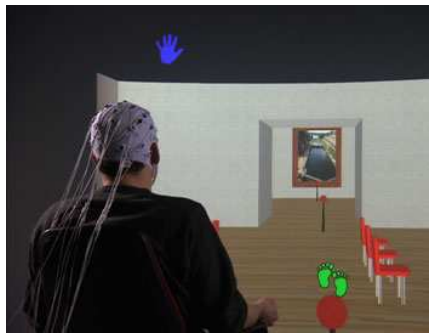
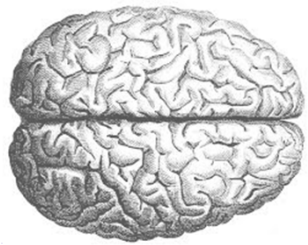
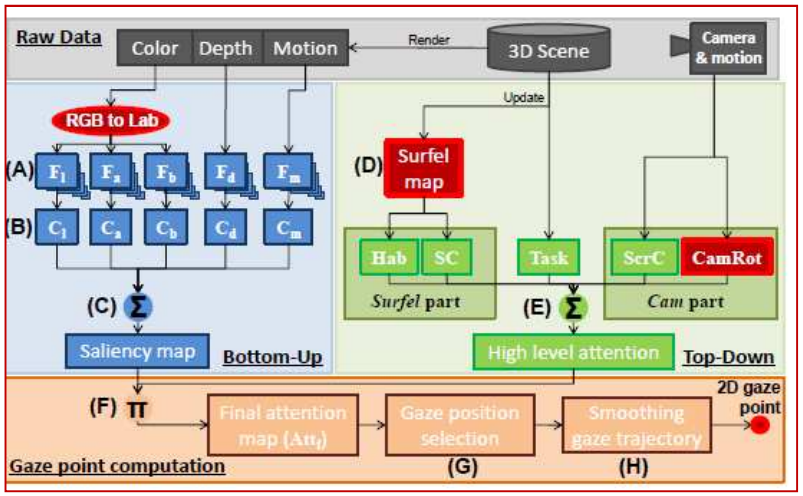
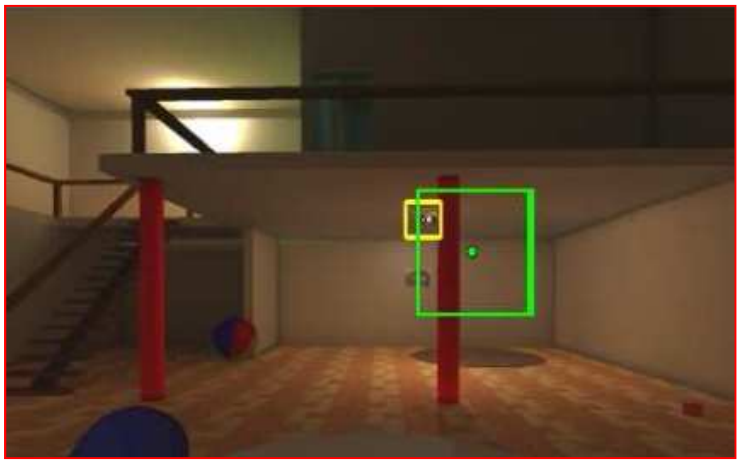




Gaze-tracking and visual attention models



(Hillaire et al., IEEE TVCG 2012)

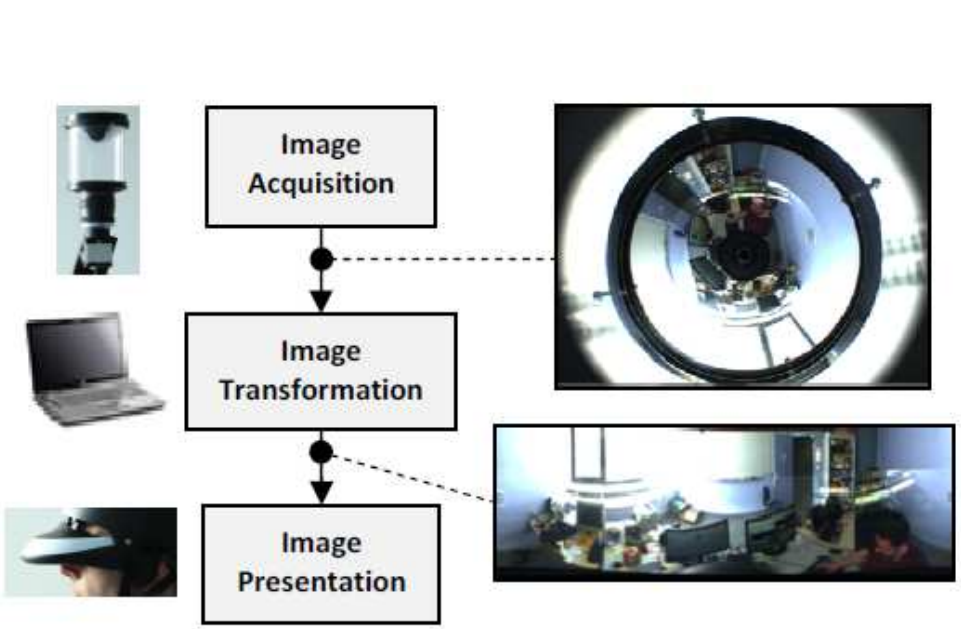


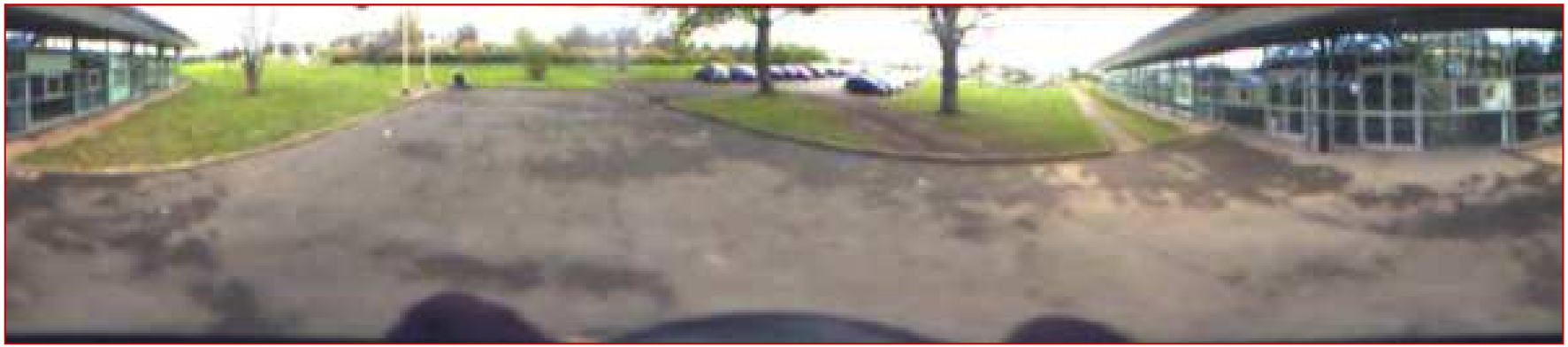
(Hillaire et al., Computer Graphics Forum 2010)

Automatic adaptation of visual rendering based on user's gaze

(Hillaire et al., IEEE VR 2008)

FlyVIZ (Ardouin et al., ACM VRST 2012)

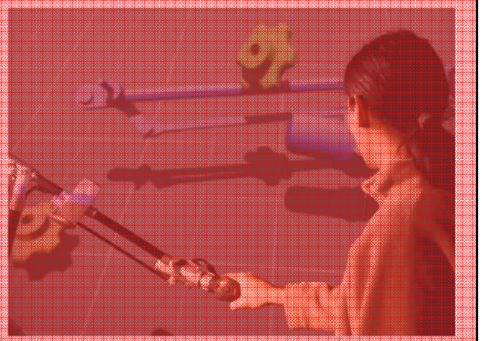




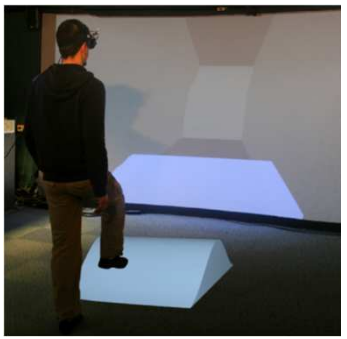
Research results

Visual Interfaces

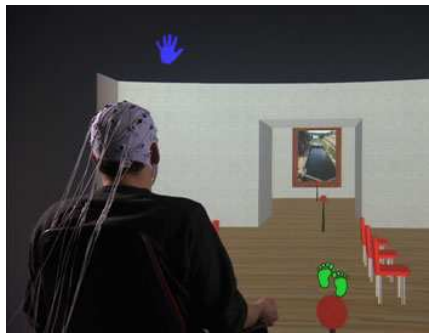
Haptic Interfaces

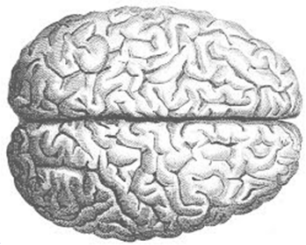


Walking Interfaces



Brain-Computer Interfaces





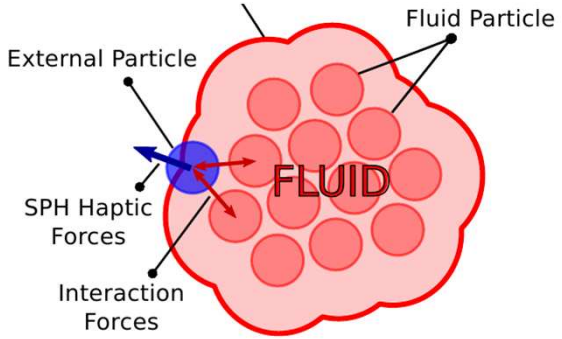
Haptic Rendering (physically-based)

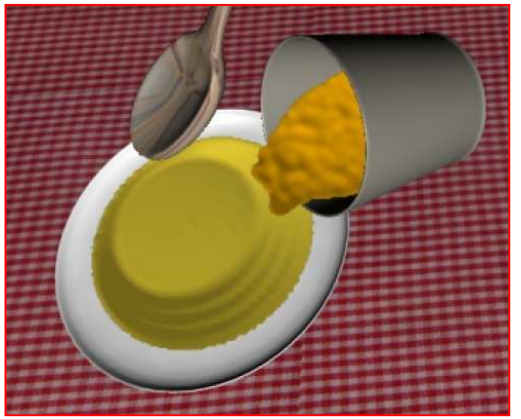
Haptic interaction with fluids

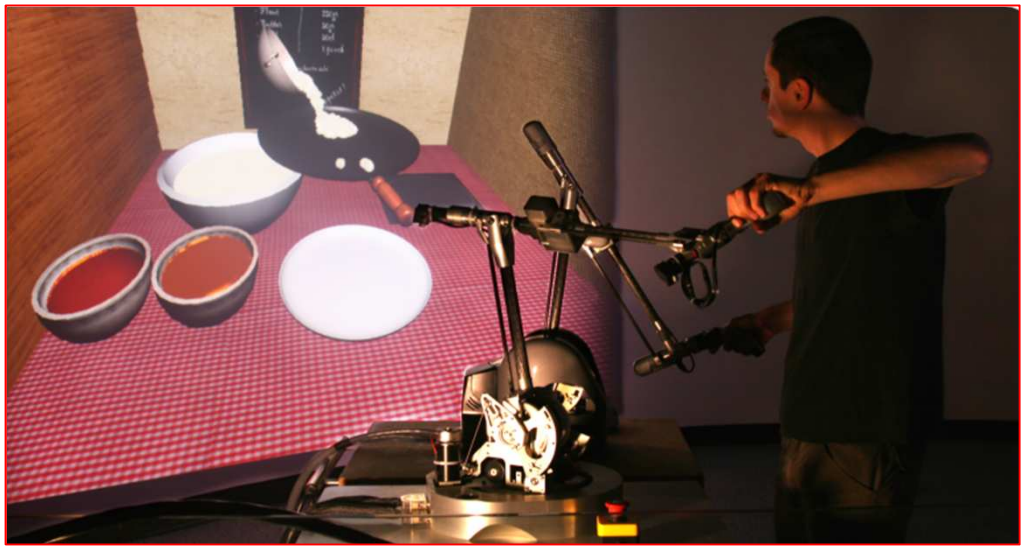
(Cirio et al., IEEE TVCG 2012)
(Cirio et al., IEEE ToH 2013)

Multi-state haptic interaction

(Cirio et al., IEEE VR 2011)



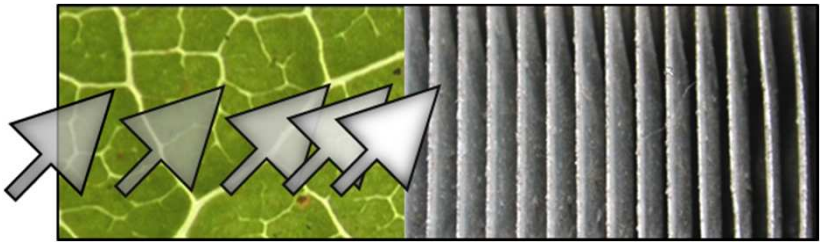


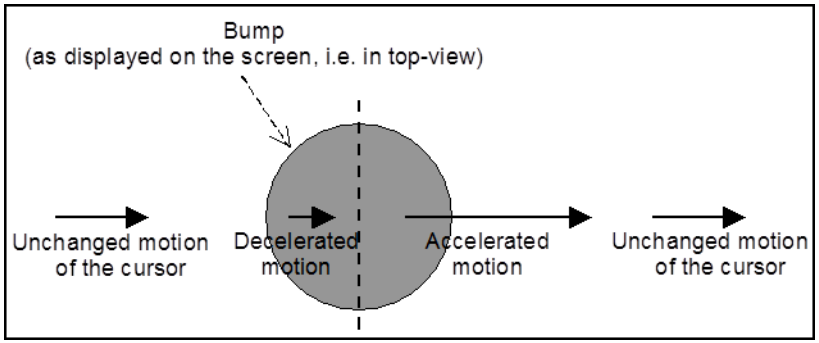


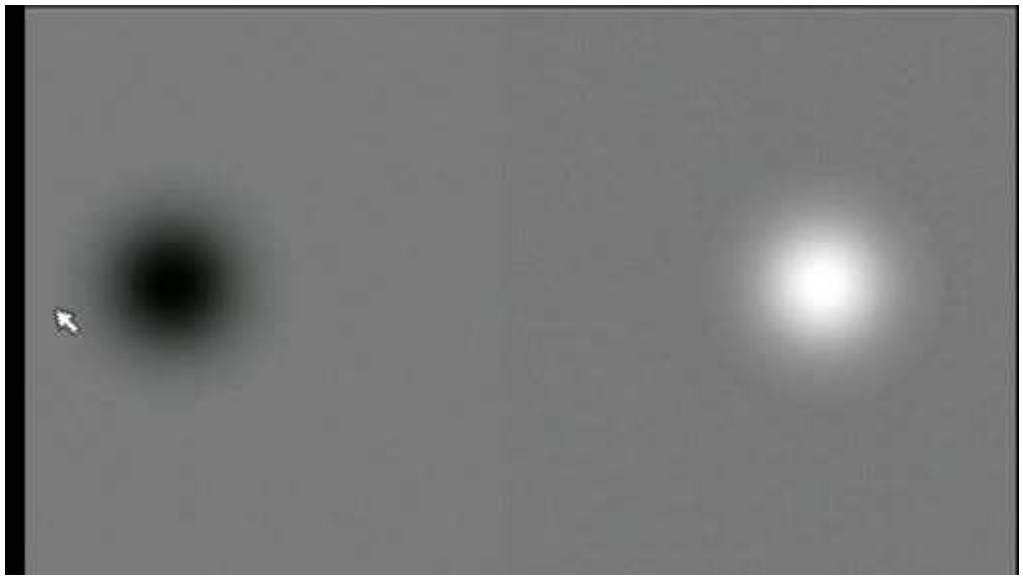
Pseudo-Haptic Feedback (perception-based)

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

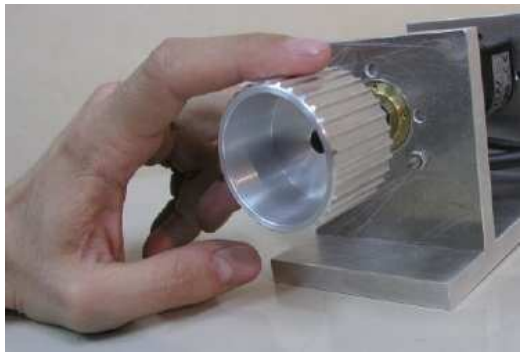
State-of-the-Art in Pseudo-Haptics (00-15)

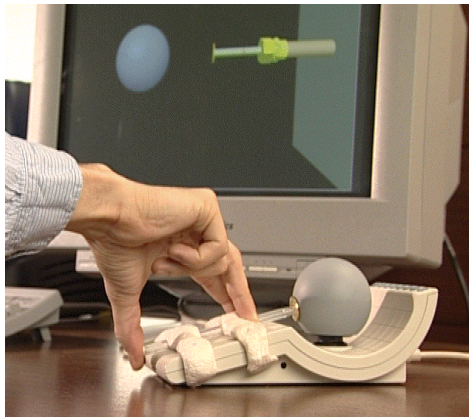
Fundamental studies:

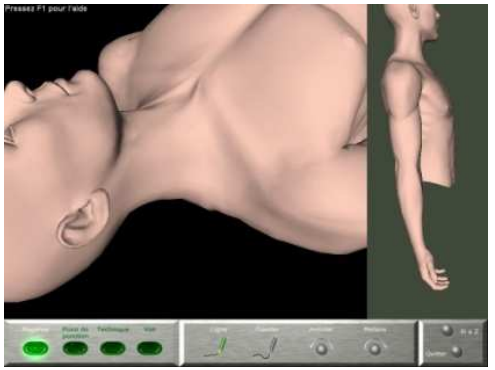
- Friction **(IEEE VR 2001)**
- Stiffness **(IEEE VR 2001)**
- Mass **(IEEE VR 2005)**
- Textures **(Eurohaptics 2010)**
- Avatars **(IEEE VR 2014)**

Applied studies:

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



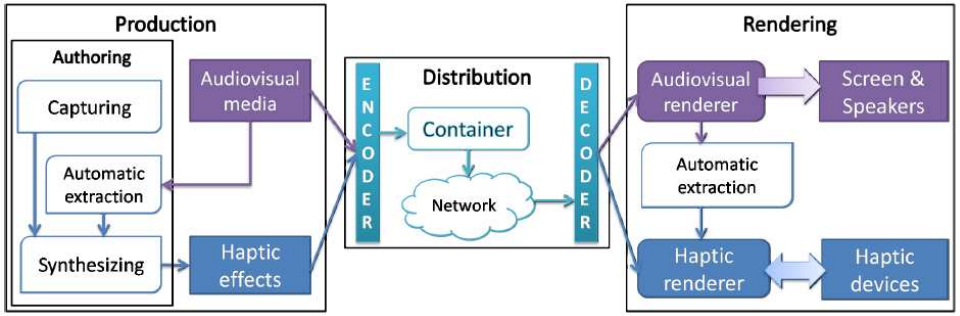




In brief: ~25 papers, 1 survey **(Presence 2009)**

Active field: +30 labs (Univ. of Tokyo, EPFL, UBC, etc)

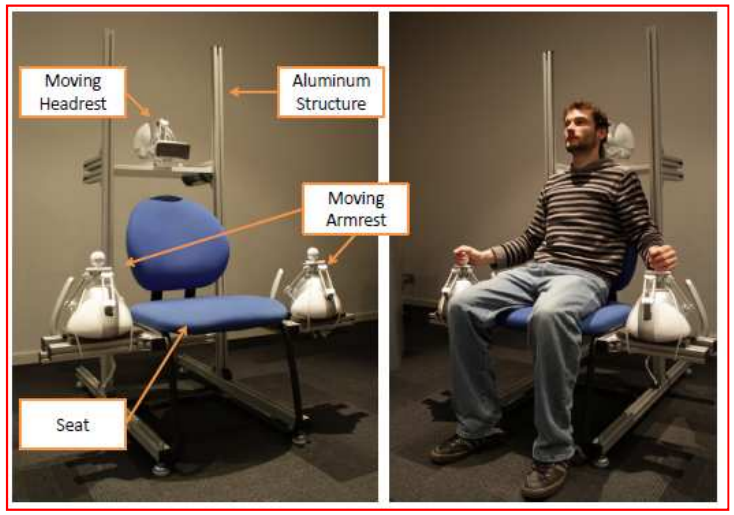
« Haptic Cinema »



technicolor

(Danieau et al., IEEE ToH 2013)

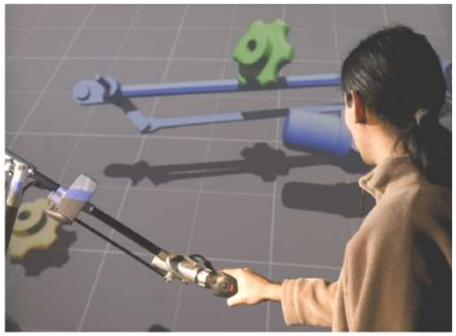
Haptic motion (vection illusion) **(Ouarti et al., WHC 2013)**
Motion effects in movies **(Danieau et al., Haptics 2012)**
HapSeat **(Danieau et al., ACM VRST 2012)**
Haptic cinematography **(Danieau et al., IEEE Multimedia 2013)**



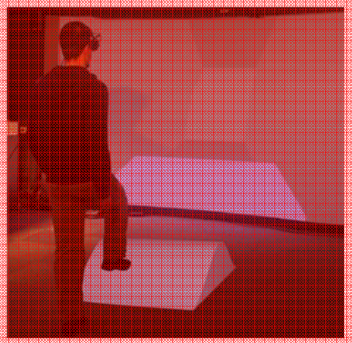
Research results

Visual Interfaces

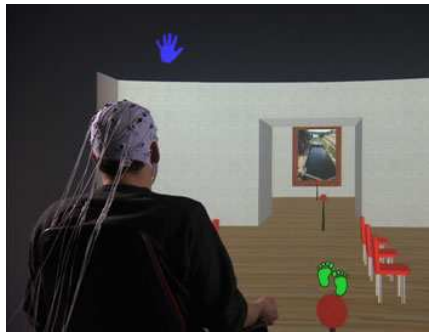
Haptic Interfaces



Walking Interfaces



Brain-Computer Interfaces



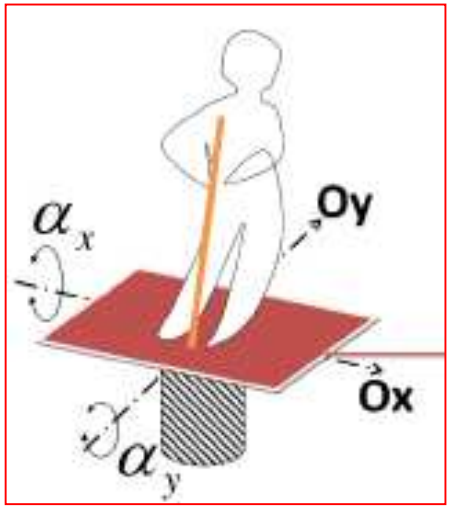
« Joyman » : Human-Scale Joystick

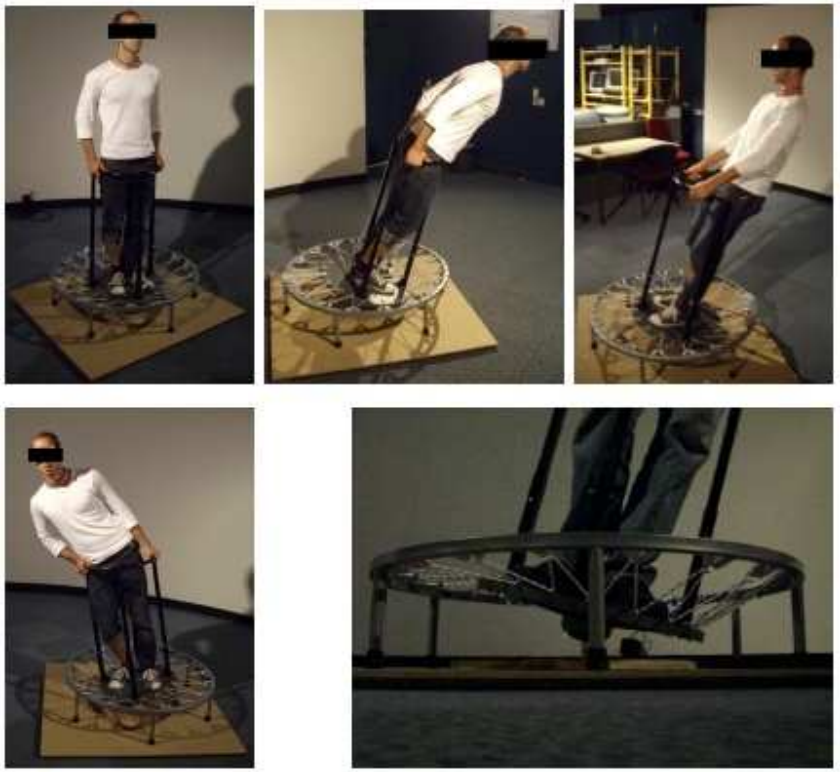
Navigation interface based on equilibrioception

(Marchal et al., IEEE 3DUI 2011)

(Pettré et al., SIGGRAPH Asia E-tech 2011)

Patent (Pettré et al., 2011)



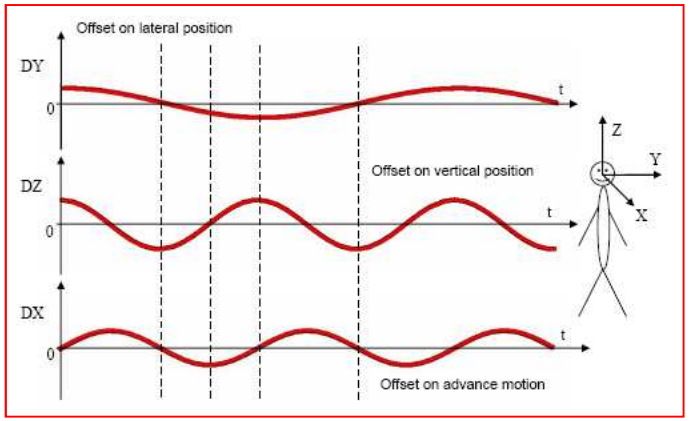


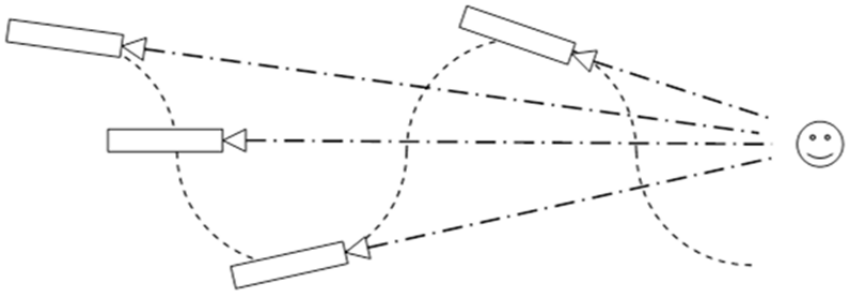
Camera motions

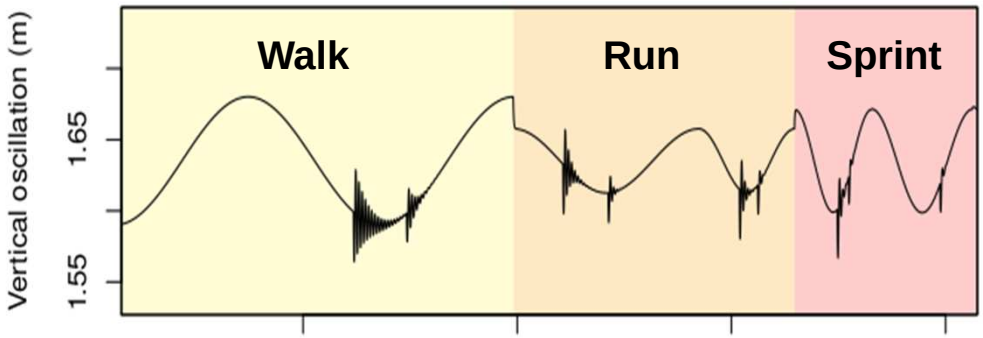
Objective : improve sensation of walking

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)







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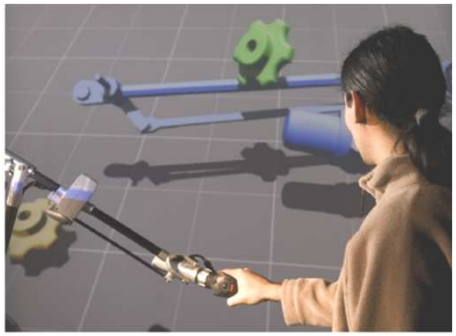
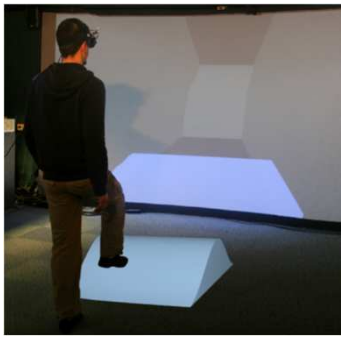


Walking Interfaces



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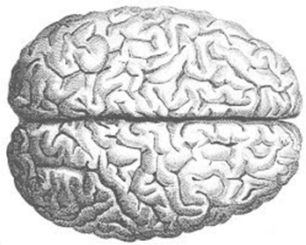
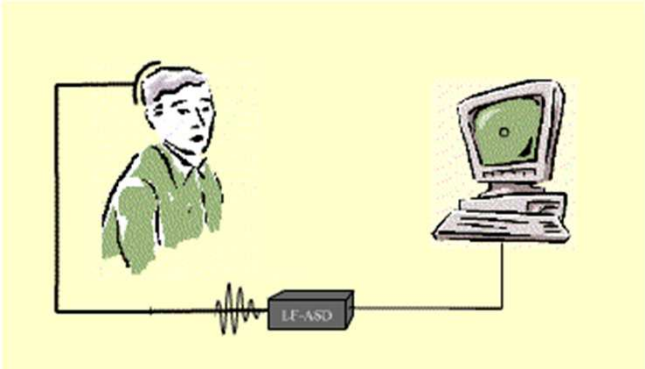


Brain-Computer Interfaces and VR

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

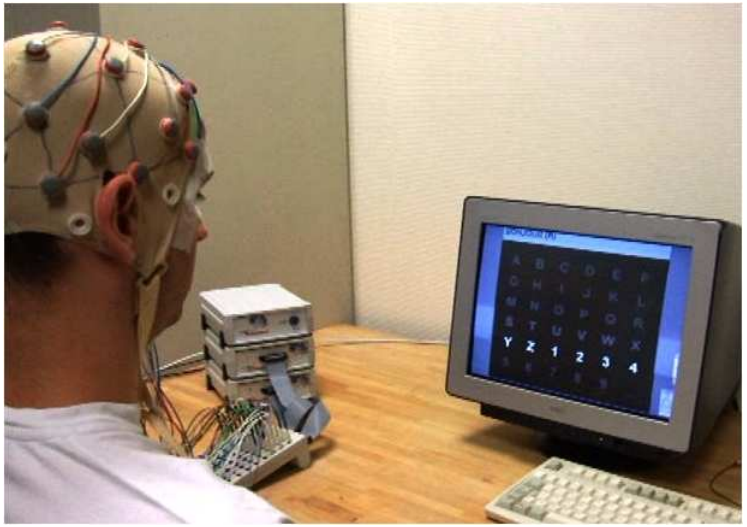
(4) Interaction paradigms

(5) Transfer to patients

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

OpenViBE1 project (2005-2009)

BCI for disabled people / open-source software

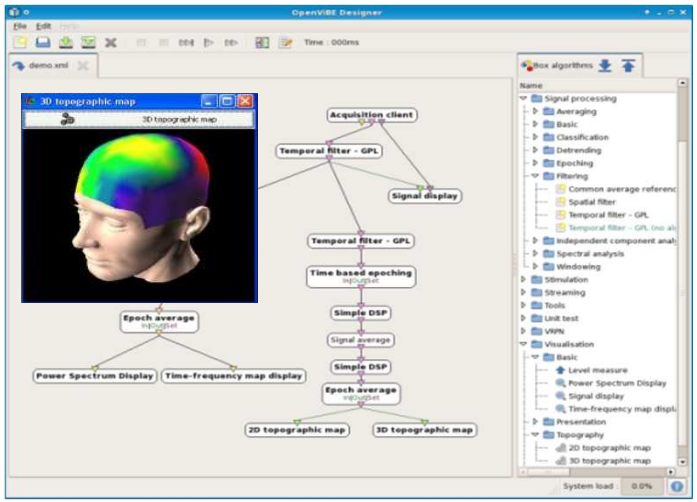


INVENTEURS DU MONDE NUMÉRIQUE

gipsa-lab

Association Française contre les Myopathies

OpenViBE software



Standard tool for BCI research

Free and open-source

Worldwide success (30K downloads)

Inria support (>2009)

>> **http://openvibe.inria.fr**

Y. Renard, F. Lotte, G. Gibert, M. Congedo, E. Maby, V. Delannoy, O. Bertrand, A. Lécuyer, *"OpenViBE: An Open-Source Software Platform to Design, Test and Use Brain-Computer Interfaces in Real and Virtual Environments"*, Presence : Teleoperators and Virtual Environments, MIT Press, Vol. 19, Num. 1, 2010

>> www.irisa.fr/vr4i/openvibe2

OpenViBE2 project (2009-2013)

from “casual” to “serious” videogames

UBISOFT

Inria
INVENTEURS DU MONDE NUMÉRIQUE

BLACK SHEEP Studio

Kt GAMES

CHART

gipsa-lab

Inserm

CLARTE

cea

HEMISFER project (2013-2016)

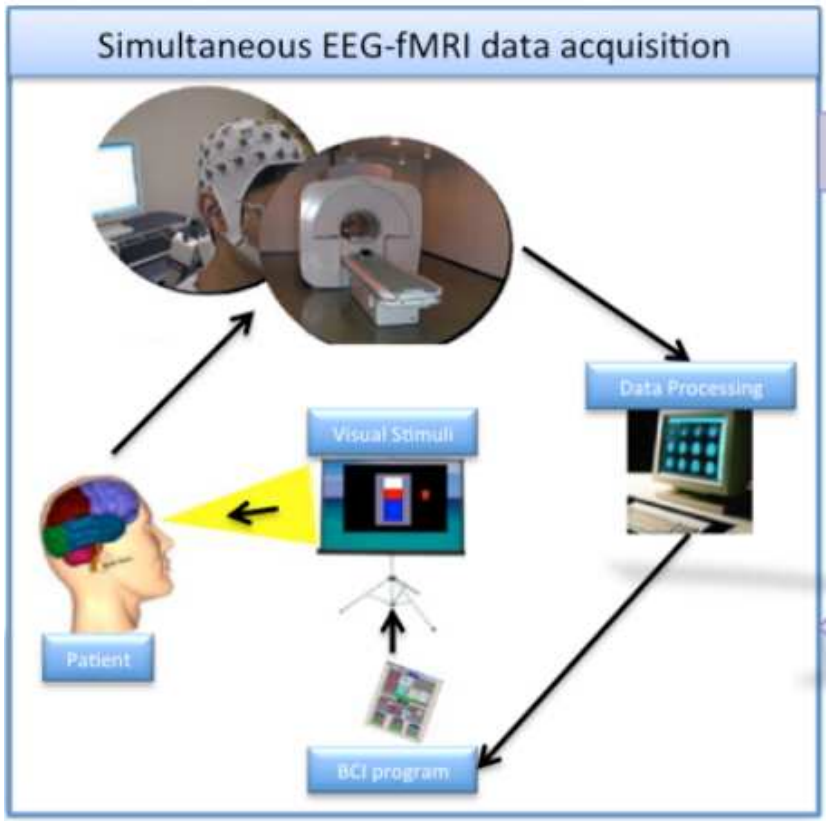
Neurofeedback based on fMRI & EEG, and VR

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)

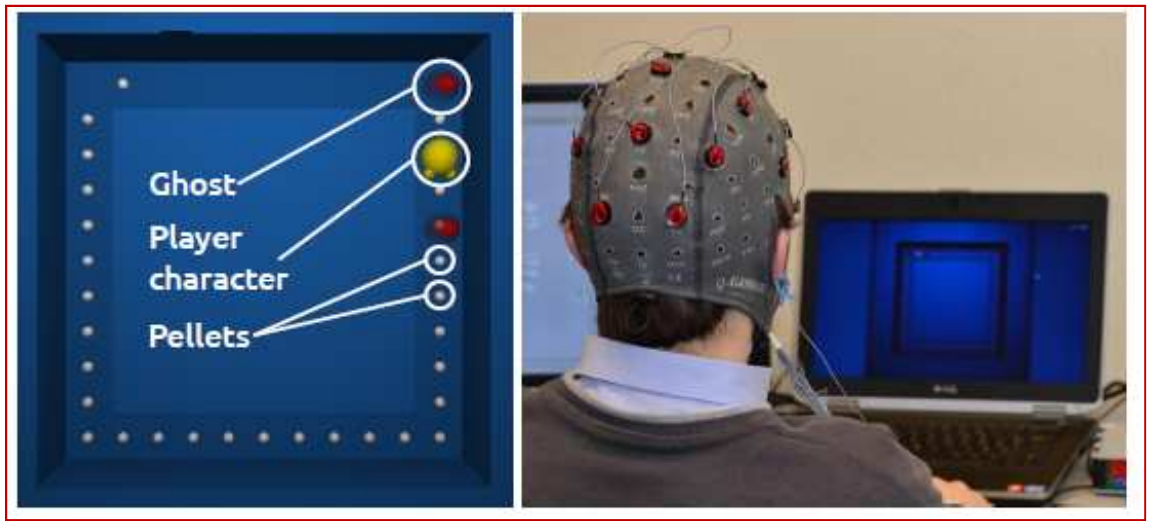
Contact:

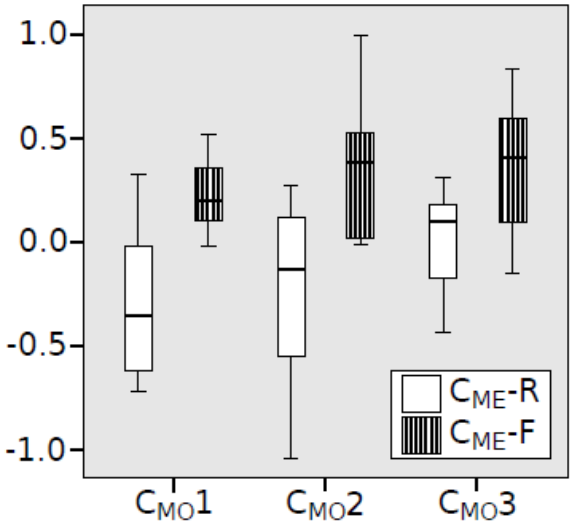
- Jean-Yves Quentel (CEO)
- Yann Renard (CTO)

>> **http://www.mensiatech.com/**

Recent results on BCI ?

Hybrid Interaction (BCI and Mouse)



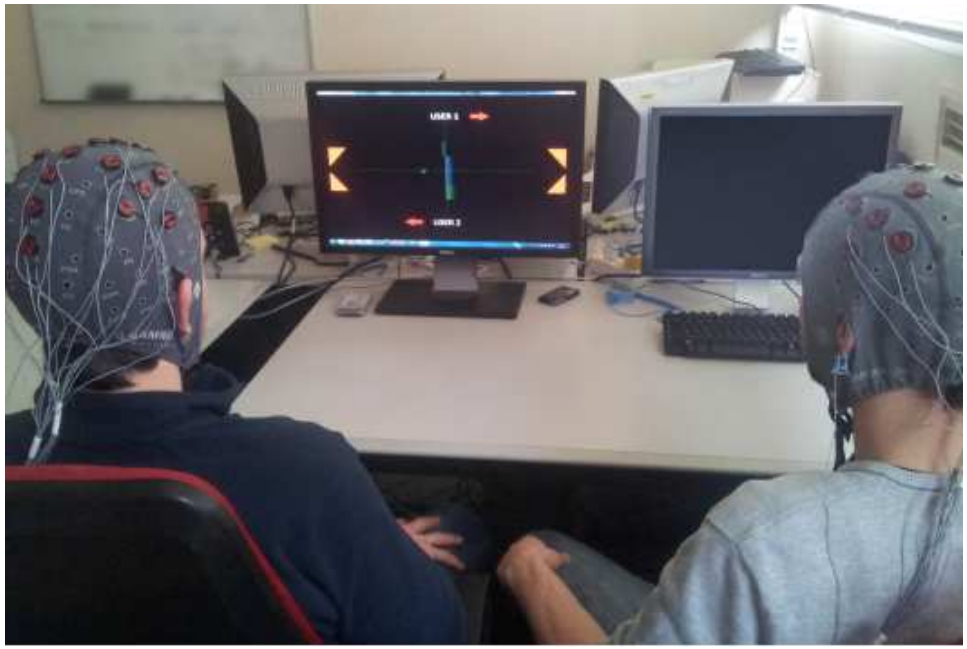


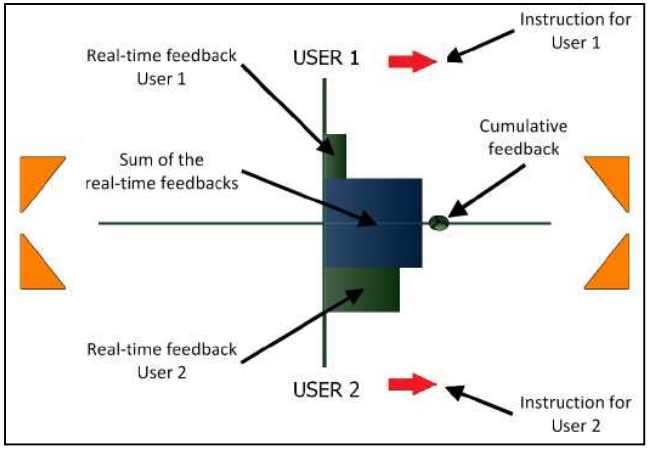
J. Mercier-Ganady, E. Loup-Escandey, L. George, C. Busson, M. Marchal, A. Lécuyer, "Can We Use a Brain-Computer Interface and Manipulate a Mouse at the Same Time?", ACM Symposium on Virtual Reality Software and Technology (ACM VRST), Singapore, 2013

Multi-User BCI

Video 1 : Competition

Video 2 : Collaboration

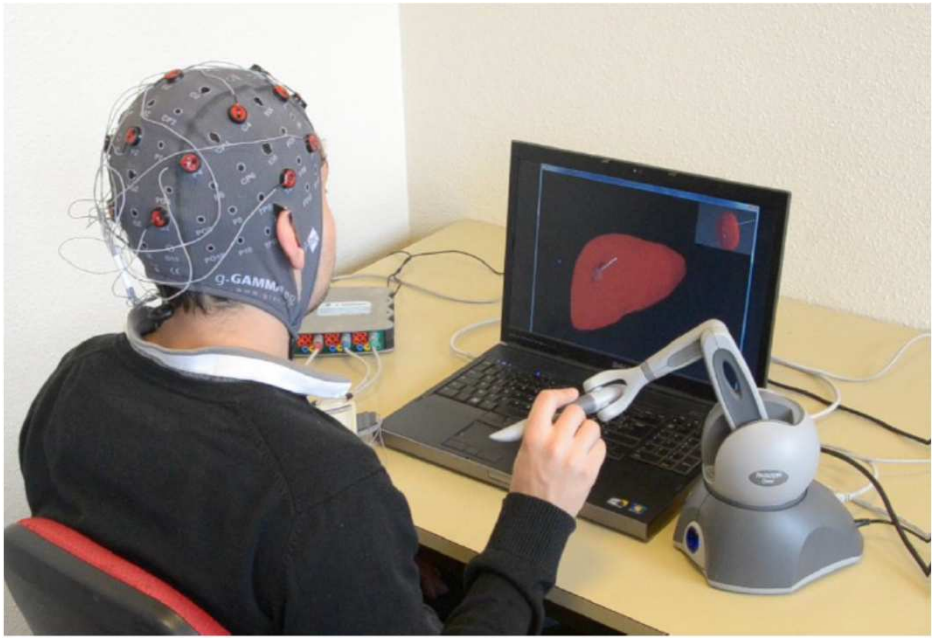


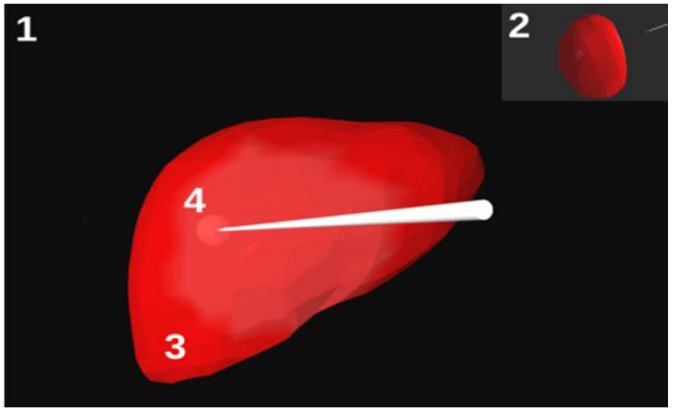


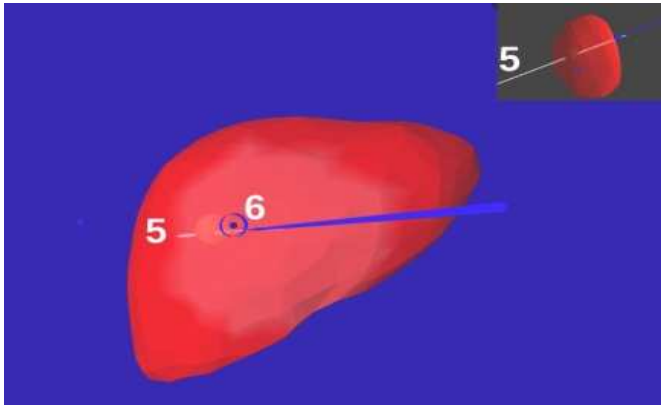
L. Bonnet, F. Lotte, A. Lécuyer, *"Two Brains, One Game: Design and Evaluation of a Multi-User BCI Video Game Based on Motor Imagery"*, IEEE Transactions on Computational Intelligence and AI in Games, 2013

Adaptive Medical Simulator (Passive BCI)

Video





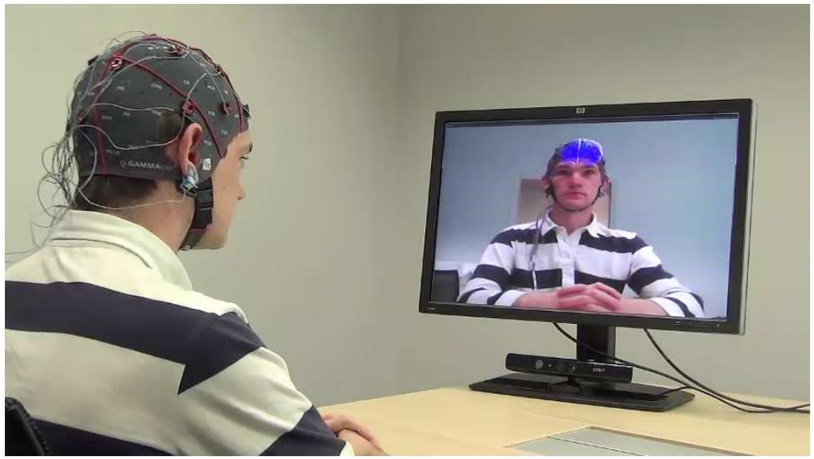


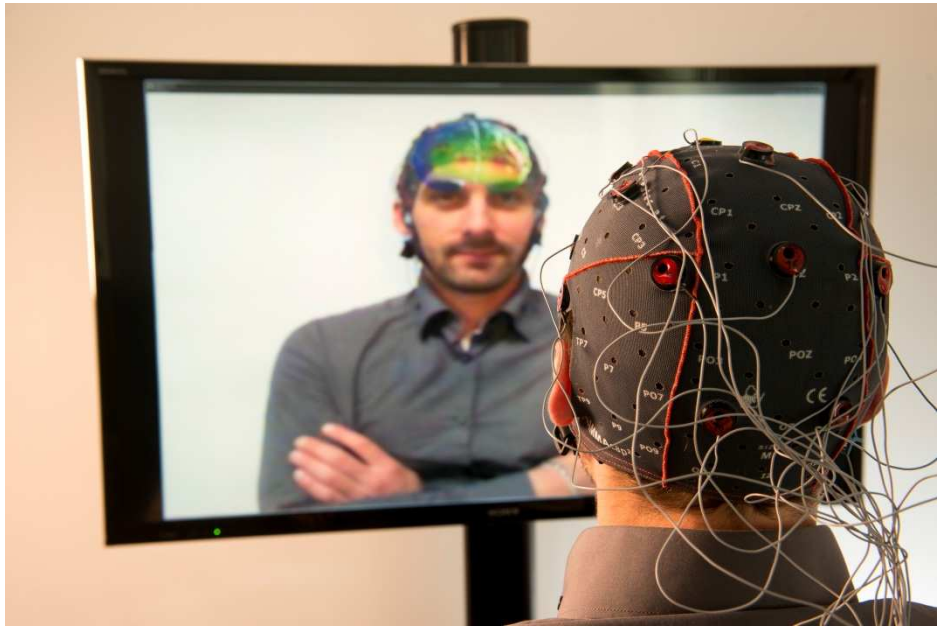
Anatole Lécuyer, Laurent George, Maud Marchal, *"Toward Adaptive VR Simulators Combining Visual, Haptic, and Brain-Computer Interfaces"*, IEEE Computer Graphics & Applications, Vol. 33, Issue 5, pp. 18-23, 2013

L. George, M. Marchal, L. Glondu, A. Lécuyer, «*Combining Brain-Computer Interfaces and Haptics: Detecting Mental Workload to Adapt Haptic Assistance*», Proceedings of Eurohaptics, pp.124-135, 2012

Mind-Mirror (Augmented Reality and BCI)

Video





Jonathan Mercier-Ganady, Fabien Lotte, Emilie Loup, Maud Marchal, Anatole Lécuyer, *"Mind Mirror: See your brain in action in your head using EEG and augmented reality"*, IEEE Virtual Reality Conference, 2014

Immersive Virtual Reality and BCI

Video

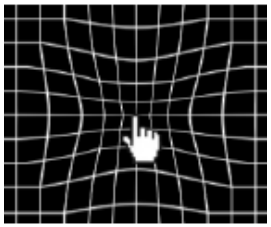
Anatole Lécuyer, Laurent George, Maud Marchal, *"Toward Adaptive VR Simulators Combining Visual, Haptic, and Brain-Computer Interfaces"*, IEEE Computer Graphics & Applications, Vol. 33, Issue 5, pp. 18-23, 2013

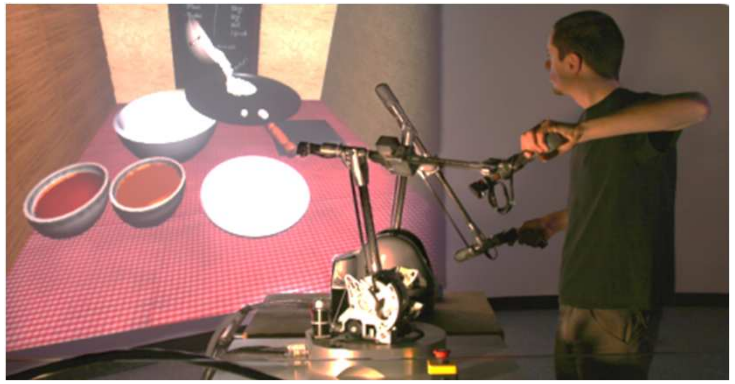
Conclusion

- ✓ 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**
PhD, Engineers, Postdoc offers >> **anatole.lecuyer@inria.fr**

Thank you !





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>> Hybrid