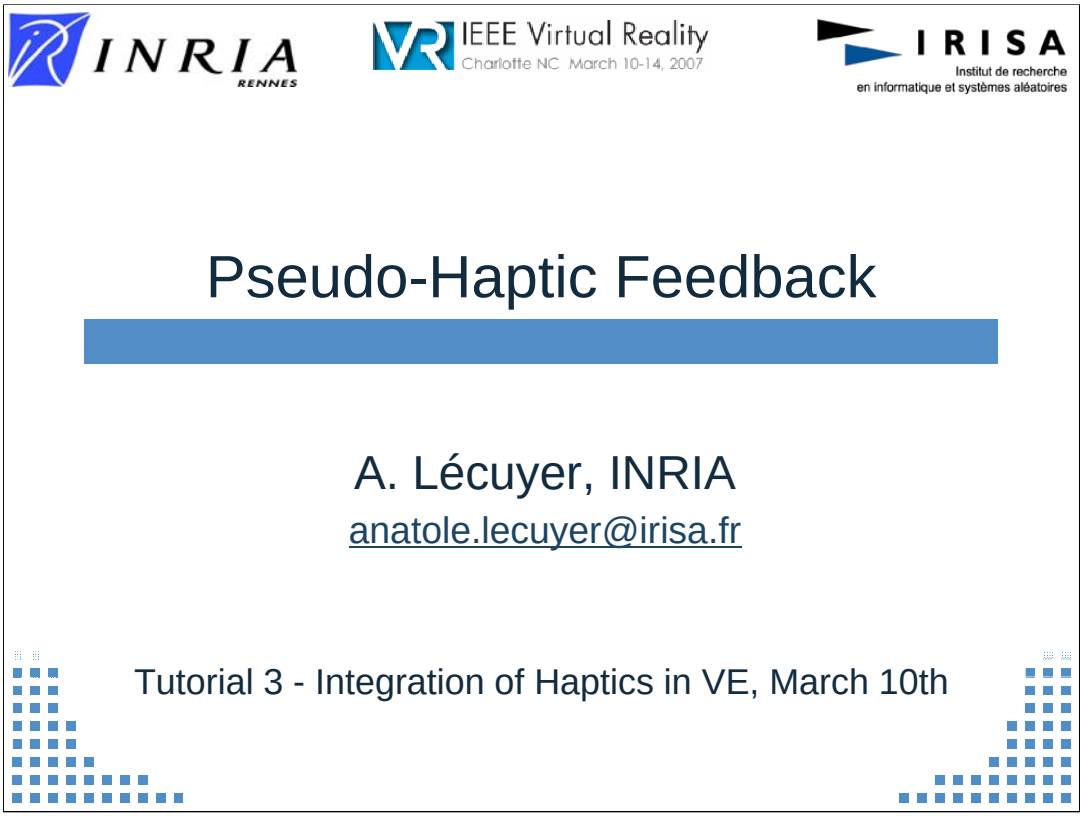

My presentation deals with a recent and novel concept in the field of haptic interaction with virtual environments : Pseudo-Haptic Feedback.

Outline

- Introduction
- Simulation of pseudo-haptic properties
  - Friction, stiffness, weight, textures
- Pseudo-haptic applications
  - Training, entertainment, GUI, medical
- Lessons learned
- Conclusion

I will describe how Pseudo-Haptic feedback (PH) has been already used to simulate different « classical » haptic properties, such as : friction, stiffness, weight, or textures.

Then I will describe how it has been transferred into several applications, such as for training in Virtual Reality, entertainment, graphical user interfaces (GUI), etc

Introduction

- Alternative to active force feedback
  - How to return force information without force-feedback device?
  - No sensory substitution or passive haptic feedback
- Possible to use passive devices (e.g. Spaceball) ?
- > Combine visual feedback with user's action

PH is an alternative to the « active » force-feedback - which requires the use of rather expensive and complex tools : the haptic interfaces.

It is not a sensory substitution; and it does not use passive feedback such as « props » [Hinckley et al.], or « tangible interfaces ».

PH makes use of visual feedback and brain plasticity to display haptic properties.

With PH, it is possible to use a passive device such as a classical computer mouse or a spaceball to simulate force-feedback. Examples will be given in the next slides.

[Lécuyer et al., IEEE VR 2000]

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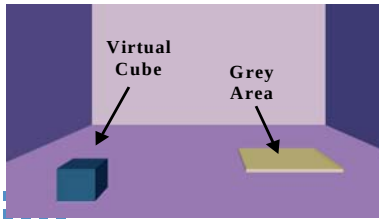
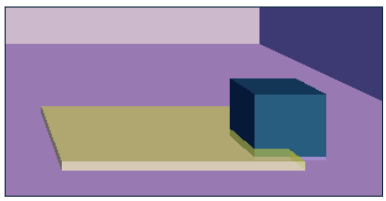
Example of Friction

- Decrease artificially visual speed of cube when crossing friction area
- Need to “push harder” on the device
- Feel resistance >> pseudo haptic fbk
- Experimental evaluation (n=18)

video





Tutorial 3 - Integration of Haptics in VE, March 10th, A. Lécuyer

Let us take the example of friction, or resistance to motion. Let us assume that we manipulate a virtual cube inside a basic virtual environment (VE).

When the cube crosses a grey area, PH consists in artificially decreasing the visual speed of the cube. This would make the user push harder on a Spaceball or on a mouse to make the cube advance and cross the slowing area. Since the spaceball is a passive and static (isometric) device, the use will receive an increasing reaction force from the device. The combination of the visual speed decrease and the increasing reaction force is assumed to be associated with a friction effect … some kind of pseudo haptic feedback.

This effect was evaluated using 18 participants who were all able to express haptic sensations when crossing the grey area. More information about this evaluation are available in [Lécuyer et al., 2000]

[Lécuyer et al., IEEE VR 2000]
[Lécuyer et al., IEEE VR 2001]

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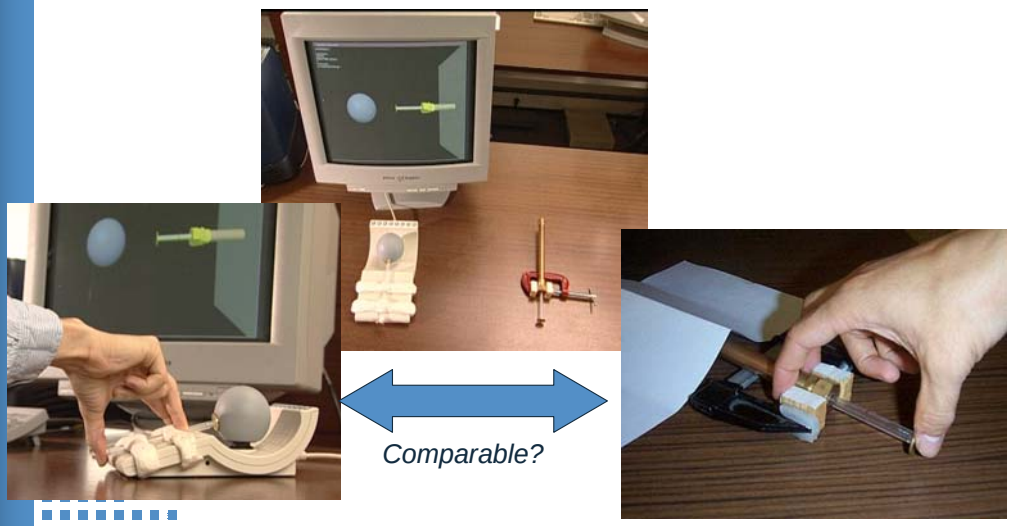
Simulation of Stiffness



Tutorial 3 - Integration of Haptics in VE, March 10th, A. Lécuyer

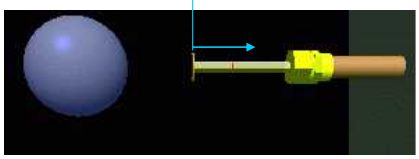
A second study was focused on the simulation of stiffness, i.e. the softness or hardness of a material.

In this study we wanted to go further and compare the sensations obtained with a PH together with the real sensations of pressing a « real » spring such as inside a trumpet piston.

Pseudo-Haptic Spring Model

Force

Visual Displacement



Hooke's law : $F = K.\Delta x$

video

$Kv = \frac{Force}{Displacement\ of\ finger}$

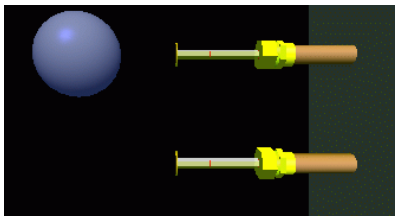
$Kv = \frac{Force}{Visual\ Displacement}$

We used a Spaceball again. On the computer screen a virtual spring is displayed, as similar as possible to the real springs used (=piston). We played with the visual displacement of the virtual spring. When amplifying visually the displacement of the spring (when pressing the spaceball), we assumed we could distort the stiffness perception. That is, the larger the visual displacement, the softer the virtual spring.

We assumed that the stiffness perceived by the participants of our experiments would then correspond to the ratio : (Force applied) / (Visual Displacement); instead of the one : (Force applied) / (Displacement of the finger) –which is constant and equals to the internal stiffness of the Spaceball. This means that by playing with the visual displacement, we can simulate a large range of PH stiffness.

Psychophysical Experiments

- Two tests
  - Virtual vs. Virtual
  - Virtual vs. Real



- Results
  - Psychophysical parameters : JND, PSE
  - Same performance V vs. R
  - Suggest comparable sensations

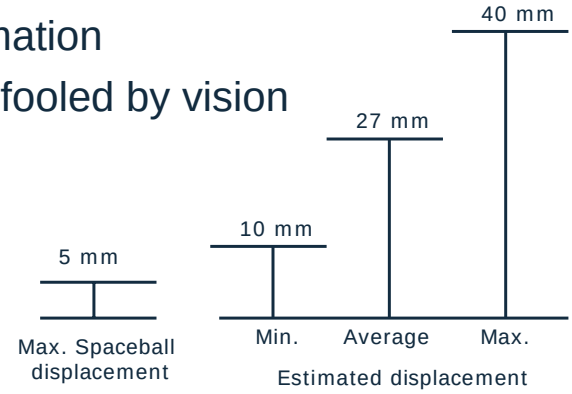
We evaluated our PH spring model by achieving a series of 2 experiments.

These experiments were grounded on psychophysics. More information about these experiments can be found in [Lécuyer et al., 2000 and 2001].

In brief, our results showed quantitatively that the perceptual performances obtained when comparing our virtual (PH) springs to a real one were similar to that obtained when comparing two real springs in reality. This suggests that the sensations provided by our PH springs are comparable and similar to that of pressing a real spring.

Haptic Illusion

- Question posed to participants:
  - “what was the max. displacement of your thumb?”
- Clear overestimation
- Proprioception fooled by vision



In addition, we asked a last question to the participants of our experiments : « what was the maximum displacement of your thumb when pressing the Spaceball during these experiments? ». People had to draw a line on a sheet of paper corresponding to this maximum displacement.

Surprisingly, it occured that participants overestimated strongly their motion (mean : 27 mm although the max motion of the spaceball is of 5 mm).

This suggests an haptic illusion, or a blurring of the proprioceptive sense by the visual feedback.

[Dominjon et al., IEEE VR 2005]

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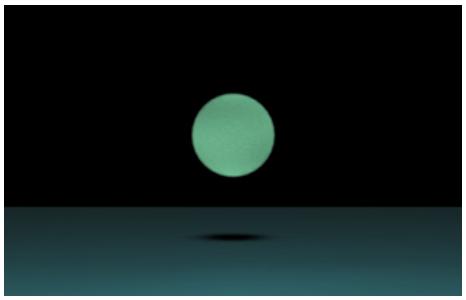
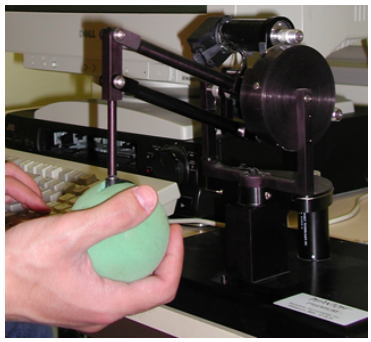
Simulation of Weight

video

- Visual motion amplification >> objects feel lighter
- Beware of Control/Display gain in haptic simulations





In another study we could also show that PH can be used to simulate mass or weight perception.

It stresses the importance of a well-known parameter : the Control/Display ratio, wich corresponds to the ratio between the real (physical) motion of the device manipulated by the user divided by the visual displacement of the object or cursor displayed on screen. For instance, a C/D ratio inferior to 1 means that the visual motion of your cursor is amplified, as compared to the real motion of your mouse.

Our study showed actually that when amplifying visually the motion of the object manipulated haptically by the user (using a C/D ratio < 1), the participants could feel that the virtual object was lighter than it was.

This result implies that strong care must be taken when setting this C/D ratio in haptic simulations, as using a C/D ratio different from 1 strongly distorts the haptic perception of the virtual environments.

[Lécuyer et al., ACM CHI 2004]

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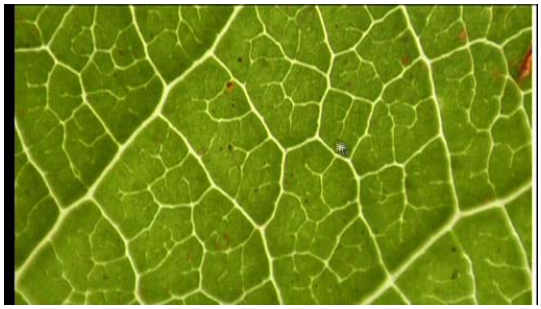
Simulation of Textures

- Simulate tactile sensations related to textures
- Give the feeling of touching images
- Use a computer mouse

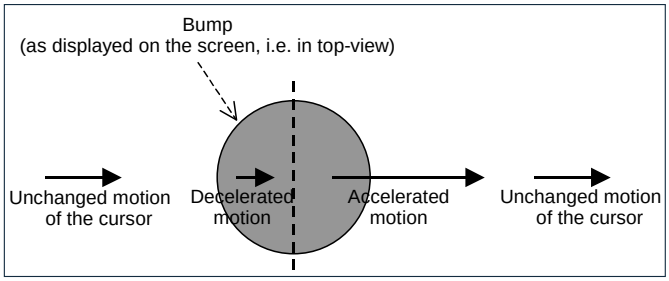


A last study investigates the use of PH to simulate the feeling of passing over a texture (e.g. a 2D image displayed on computer screen) and perceiving the relief of it.

To do so we simply use a computer mouse.

Pseudo-haptic textures

- Modify the motion (speed) of the cursor
- Change the Control/Display gain as a function of the height
- Simulation of a bump



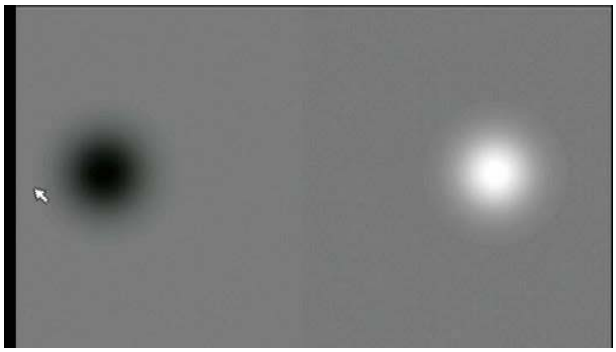
The simulation of pseudo-haptic textures relies on a modification of the motion (speed) of the manipulated mouse cursor.

We change artificially the C/D ratio as function of the height of the terrain the cursor is passing over.

For instance, to s

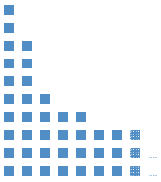
Bumps and holes (video)

- Web demos : www.inria.fr/tactiles
- Local demos here



Applications

- Training simulator
- Tactile Images
- GUI
- Medical simulator

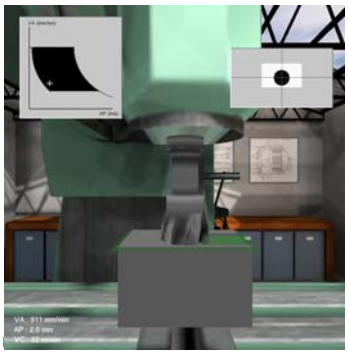


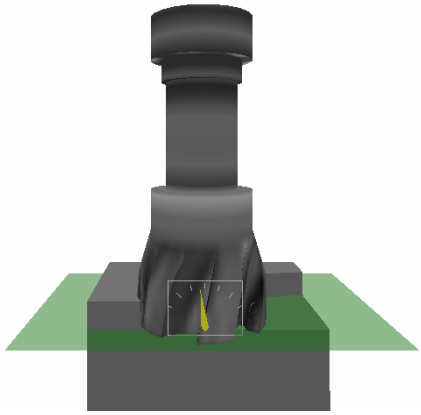
[Crison et al., Eurohaptics 2004]
[Crison et al., IEEE VR 2005]

Training simulator : VTT

- Virtual Technical Trainer (VTT)
- Vocational training to milling machines
- Interactive cutting/milling

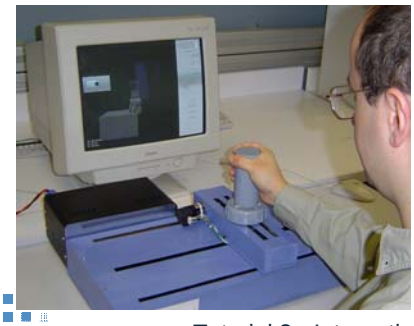
video

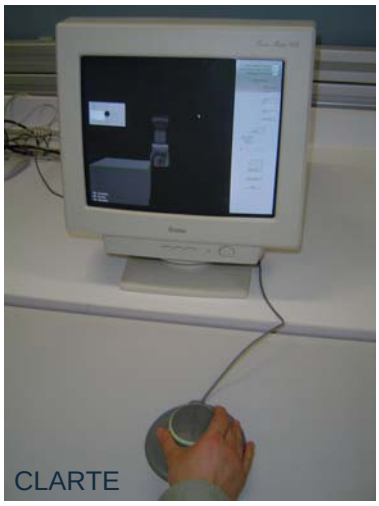




Pseudo-Haptic in VTT

- Use of SpaceMouse
- Perception of cutting effort
- Influence of: rotation speed, type of material, etc





Tactile Images

- IFeelPixel Software
  - Real haptic, sound, pseudo-haptic
  - Perception of depth/textures of images/pictures
  - Applications: web, games, etc
  - free download: www.ifeelpixel.com

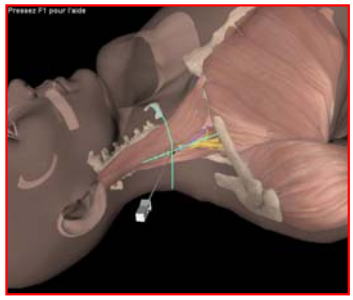
[Mandryk et al., ACM CHI 2005]

Graphical User's Interface

- Pseudo-haptic widgets :
  - « classical widgets such as icons or sliders augmented with pseudo-haptic effects »
- Effects : sticky, magnetic, repulsive, etc
  - "Users are more efficient with pseudo-haptic widgets" : faster, less errors

Medical Simulator

- Training to nerve stimulation in regional anesthesia
- Palpation before insertion of needle
- Pseudo-haptics : detection of hollow, organs



Bibin (Univ. Paris 5) « Peripheral nerve Blocks on DVD : Lower and upper limbs », Lippincott Williams & Wilkins

Lessons learned (1/2)

- Specificity of pseudo-haptic feedback
  - Different from : « real » haptics, sensory substitution, props
- Inter-individual variability
  - Necessary tuning and calibration
- Use of input devices
  - Preference for elastic devices :
    - better than isometric devices, than isotonic devices?

Lessons learned (2/2)

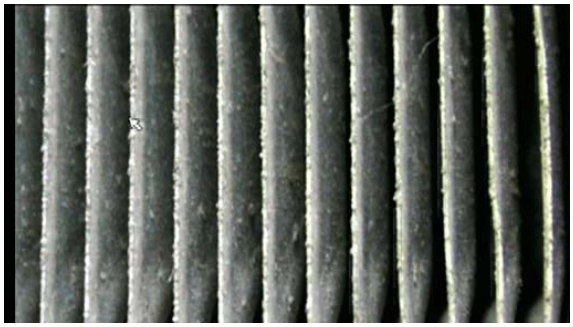
- Use of the C/D ratio
  - Adaptation of C/D ratio (C/D ratio $\neq$ 1)
  - >> Sensory-conflict on visual displacement
  - >> Visual dominance
  - >> Re-formatting for internal consistency
  - >> pseudo-haptic model
  - ..Future work

Conclusion

- Pseudo-haptic feedback :
  - New technique to simulate haptic properties based on visuo-haptic combination
- Successful simulation of haptic properties: friction, stiffness, weight, textures
- Transferred in several applications: training, medical, entertainment, etc

Thank you

- Questions ?
- *Demos at : www.inria.fr/tactiles*



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