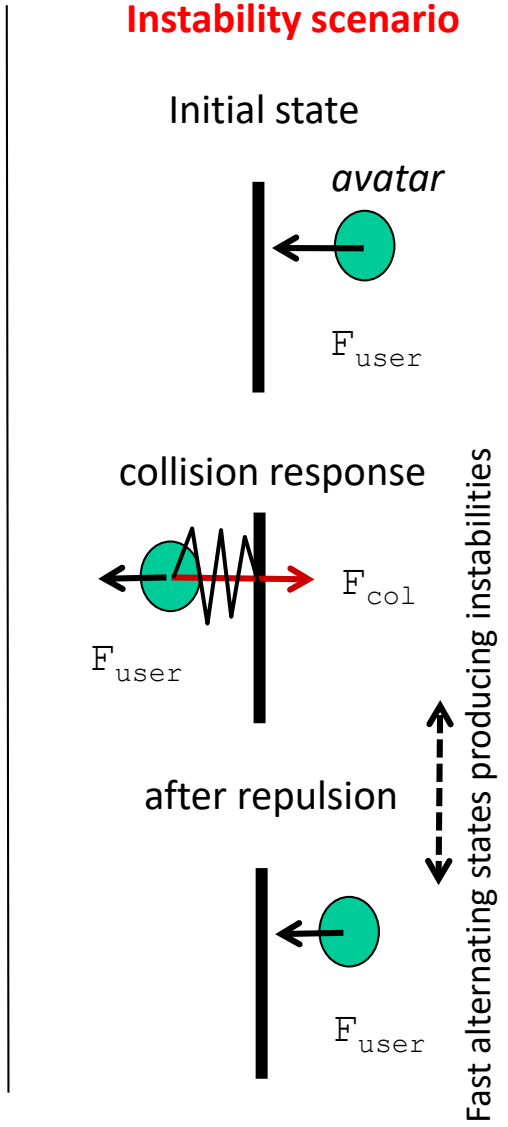
# *Haptic interfaces*

1. Definition, scope and history
2. Haptic display characteristics
3. Haptic display types
4. Haptic design guidelines
5. Haptic interaction through virtual coupling
6. From Haptic to pseudo-haptic feedback

***video3***

# 5. Haptic interaction through virtual coupling

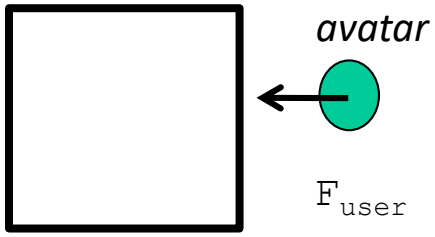
- Requested haptic control update rate: min 600 Hz up to 1 KHz – 2 KHz
  - Otherwise instabilities or the haptic sensation is too soft.
  - But 1 KHz /1ms is not sufficient for updating & displaying the whole state of the VR interaction
    - Difficult to prevent a visible interpenetration
  - Solution: coordinate two systems [M 1996]:
    - haptic rendering updated at 1 KHz
    - simulation and graphical update at 20 Hz - 60 Hz
    - coordination through ***Virtual Coupling [L 2006]*** with the concept of **proxy**, named **god object** in [Z 1995])



# 5. Haptic interaction through virtual coupling (2)

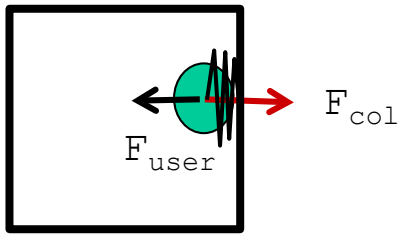
- Improving the **avatar** with the **proxy** [Z 1995, TVR Vol3, LO 2006]
  - Goal: encapsulate the *history* of the interaction to prevent arbitrary discontinuity in the computation of the collision response (rigid objects)

Initial state

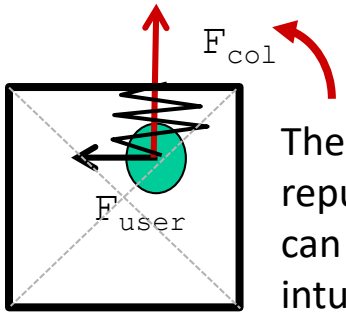



The **avatar** and the **proxy** coincide when there is no collision

**collision response without proxy**:
the avatar may sink into the object…



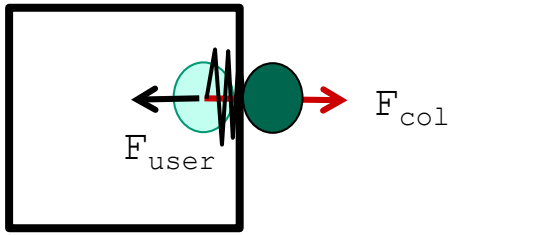

…and if the user pushes a bit deeper one gets closer to a different surface

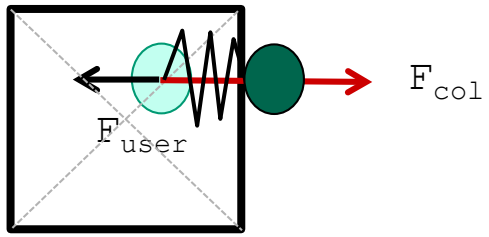



The change of repulsion force can be large/not intuitive

Tracked user location

collision response with **proxy**
(only the **avatar-proxy** is displayed)



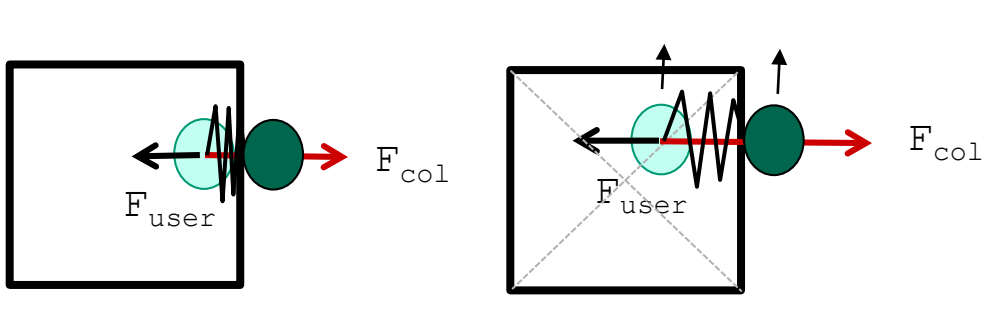




The proxy preserves the coherence of the interaction

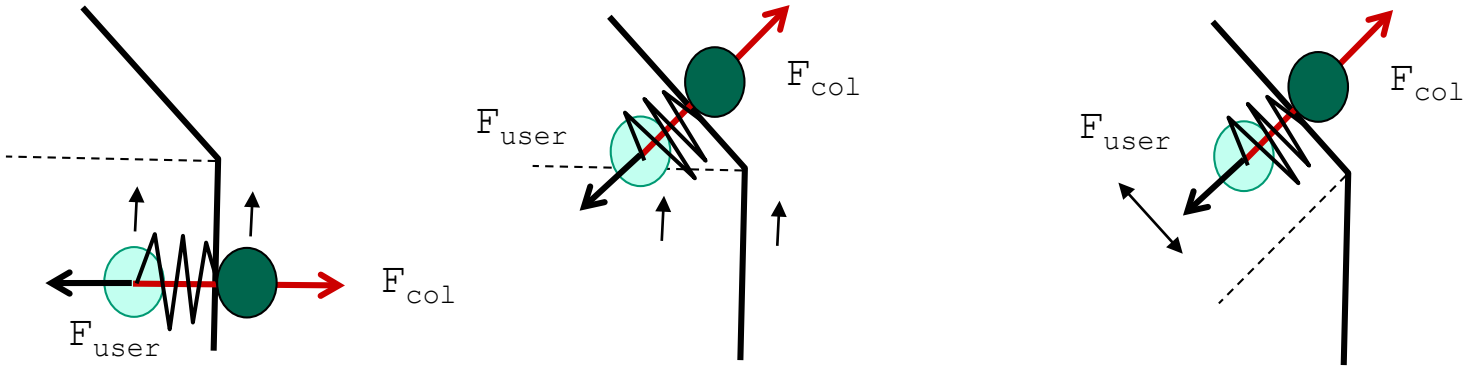
# 5. Haptic interaction through virtual coupling (3)

- Tracking the **proxy** across polygons[H2000]

Tracked user location  collision response with **proxy**  (only the **avatar-proxy** is displayed)




The proxy preserves the coherence of the interaction ; however some discontinuity is still possible




condition for polygon switching

the new polygon normal defines the boundary for polygon switching

Typical complexity for N polygons [H2000]:

First intersection: log(N) provided the meshes are organized with hierarchical bounding boxes or similar approach (cf UNC GAMMA project)

Tracking the intersection is in O(1) because only neighbour polygons are explored

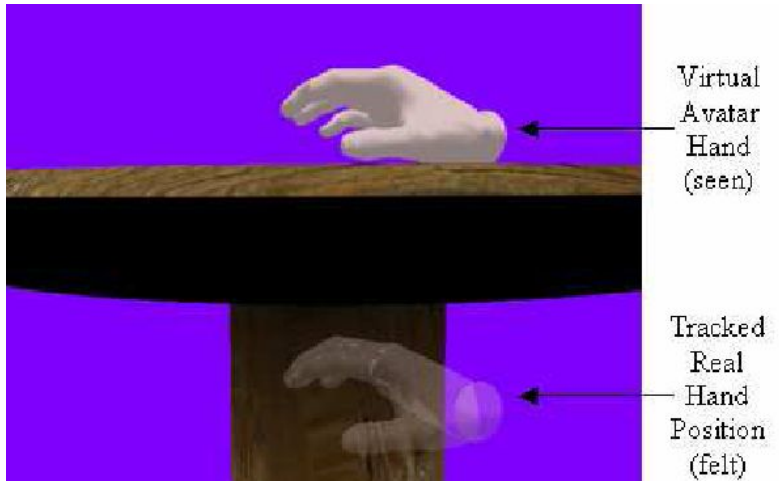
# Implementation of the avatar-proxy concept

with the Haptic
- Workstation = 2 CyberForce & Cybergrap

The proxy concept is
- extended to the full articulated hand [Ott et al 2008] ( .avi)

# 5. Haptic interaction through virtual coupling (3)

The sink-in problem [B2006]



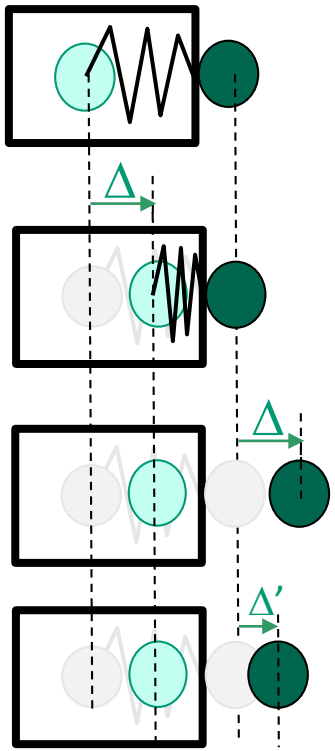

The avatar-proxy solution [B 2006]

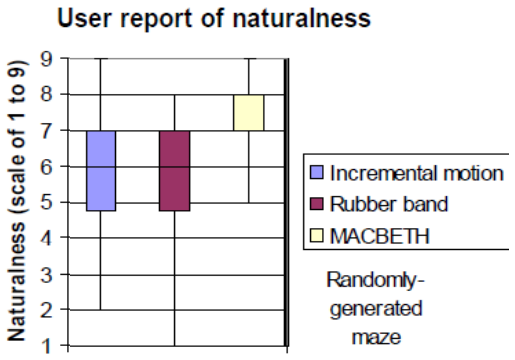
- But the **proxy** induces a visual-proprioceptive discrepancy [B 2006]
  - Translation: what the user sees does not match exactly with the current arm posture
    - Example: in case of a hand avatar: it is not displayed exactly where it should be in space. The user hand is **no more co-located** with its visual representation.

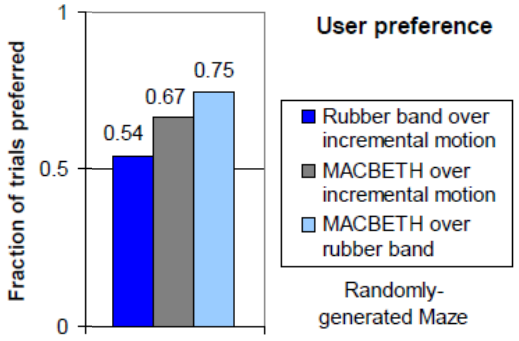
Question: is such visual-proprioceptive discrepancy more disturbing than seeing the correct location of the virtual hand sinking in a virtual obstacle ?

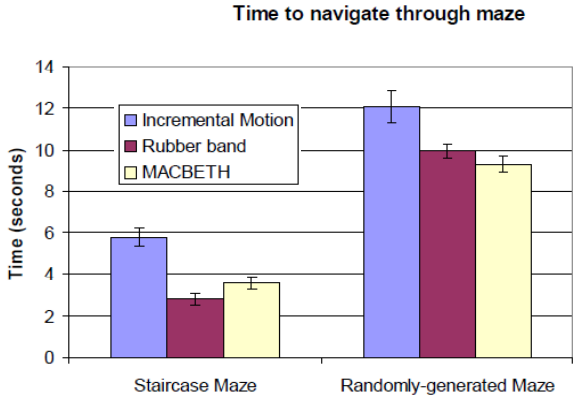
# 5. Haptic interaction through virtual coupling (4)

- **E. Burns** et al study, at UNC [B 2006] showed that users are less sensitive to small posture missmatch than to visual sink-in, i.e. *vision* dominates *proprioception*.
- Additional study in [B 2007] regarding the ***retraction*** phase, when the ***user moves backward***, *e.g. by a quantity* $\Delta$ . Compared 3 methods:
  - ***rubber-band*** : the proxy does **not move** until the avatar reaches it
    - *Velocity discrepancy*
  - ***Incremental motion***: the proxy start moving backward **with exactly the same quantity** as the user
    - *Position discrepancy (detection threshold = 20 cm)*
- ***Hybrid technique MACBETH*** : the proxy makes a ***scaled*** movement allowing to progressively reach back the tracked user hand.



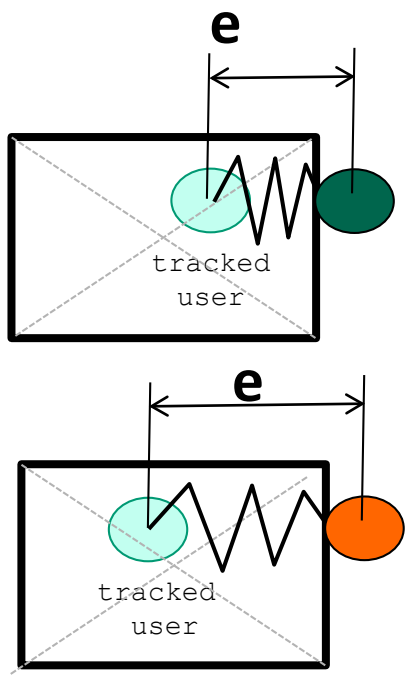
# 5. From Haptic to pseudo-haptic feedback

- The **avatar-proxy** management and display is possible even without haptic device.
- Pseudo-haptic: Instead of synthesing a force it is possible to render the error between the **tracked user** and the **avatar-proxy** through an alternate modality (visual, audio, ...)

The error **e** can be used to modulate the *rendering* of the avatar-proxy and/or the interacting object.

More than a single sensory channel can be used as substitution channel:

- ***visual*** (color, texture, special particle effects, etc…)
- ***audio*** (modulated sound).
- ***reduced avatar movement velocity*** to model friction or moving through a more viscous medium




- For complex interaction such as grasping, it is recommended to model the interaction with an assistive automaton [D2020] to make the right decision at the right moment.

# On-going research

- **Interaction with deformable tissues** (e.g. training surgery)
- **Training minimally invasive surgery**

# [Software Development Kits & Libraries]

- **UNC Gamma** software resource on **fast collision detection :**
  http://gamma.web.unc.edu/software/
- **Sensable** GHOST SDK / now OpenHaptics Toolkit
- **Force Dimension** Haptic SDK / **CHAI3D** open source lib
- **Haption** IPSI library for Catia TM
- **Immersion** MOTIV TM SDK for tactile effects on Android mobile phones
- **Reachin** & HAPTX Software products
- **SOFA** www.sofa-framework.org for physics-based deformation
- Physically-based Simulation: **Nvidia** PhysX(in Unity3D), **Bullet.org**

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