Current Issues in Haptic Rendering Using Mobile Haptic Interfaces

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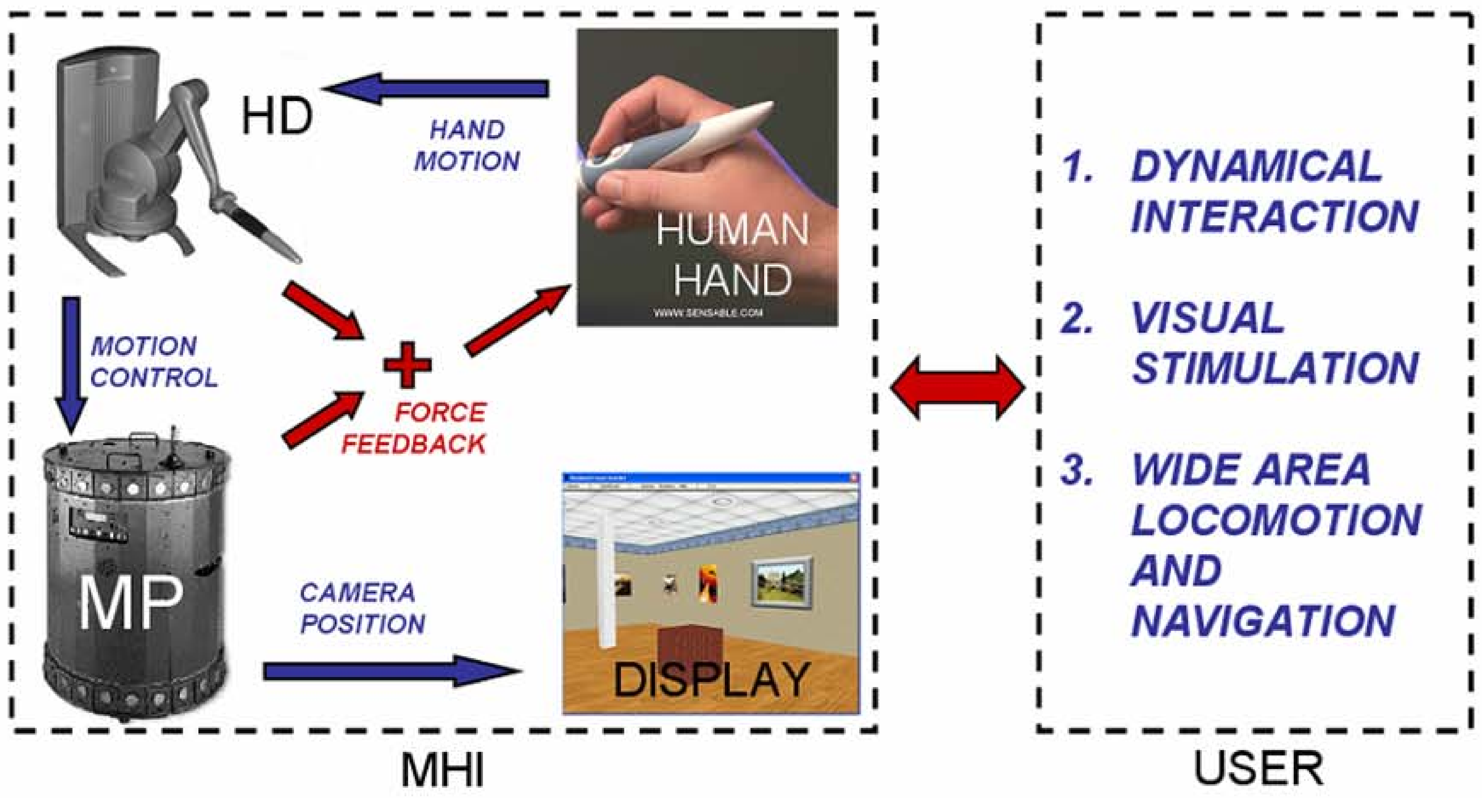
INTRODUCTION

Haptic Research recently focused on the extension of the simulation workspace. To this purpose, one of the most interesting systems is the ***Mobile Haptic Interface*** (MHI), that allows user's locomotion and navigation in large virtual environment.

Two experimental MHIs: the PHANToM with non-holonomic Pioneer2DX (left), and with holonomic Nomad XR4000 (right)

Target environment: a virtual room

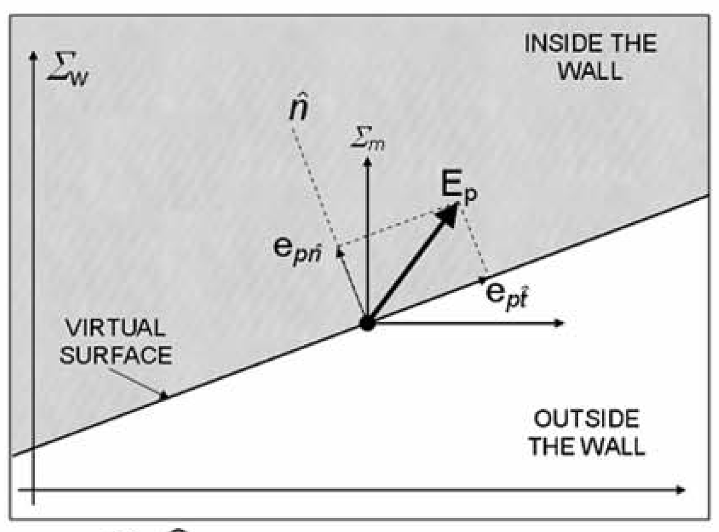
The MHI is realized by combining a common force feedback haptic device device (HD) with a position controlled mobile platform (MP). Generally a MHI features kinematic redundancy with force/position controlled dynamics.

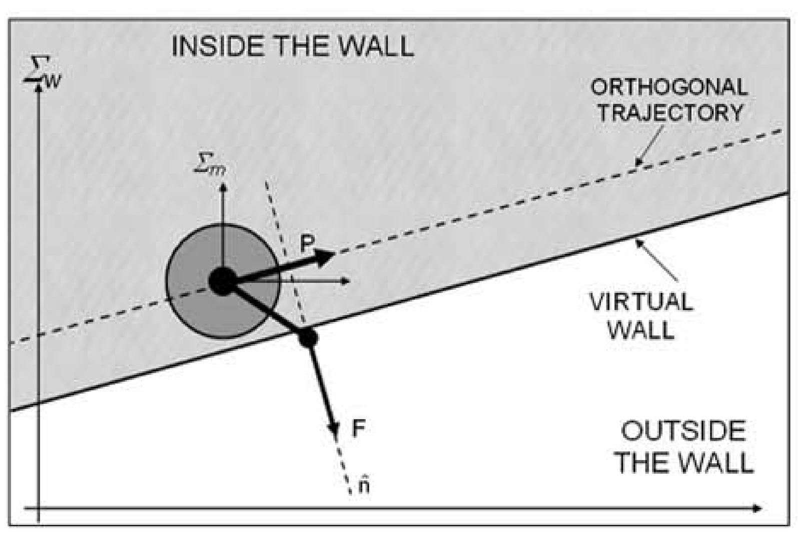


The realism of haptic rendering using a MHI is a remarkable issue.
The end-effector position inside the virtual environment and the rendered forces depend on both the HD and the MP. The main problem in haptic rendering is that the dynamical contribution of the MP on the rendered force is undetermined being the MP position controlled.

BASIC IDEA – Constrained Motion

Kinematic redundancy of a MHI can be reduced by constraining MP motion according to the following geometrical decomposition:





($\hat{n}, \hat{t}$ are the normal and tangent to objects surface at the contact point)

Orthogonal decomposition: $\begin{cases} e_{p\hat{n}} = \langle E_p, \hat{n} \rangle \\ e_{p\hat{t}} = \langle E_p, \hat{t} \rangle \end{cases}$

When a collision is detected and forces are rendered, the **orthogonal decomposition** of E_p (the vector pointing to the haptic probe from the proxy) is performed.

The orthogonal decomposition provides the following features:

1) the vector $e_{p\hat{n}}$ can be applied to the local object model in order to compute the force F to be rendered to the user;

2) the vector $e_{p\hat{t}}$ can be applied to the MP motion controller in order for MP accelerations $\ddot{P}$ to be orthogonal to rendered force F .

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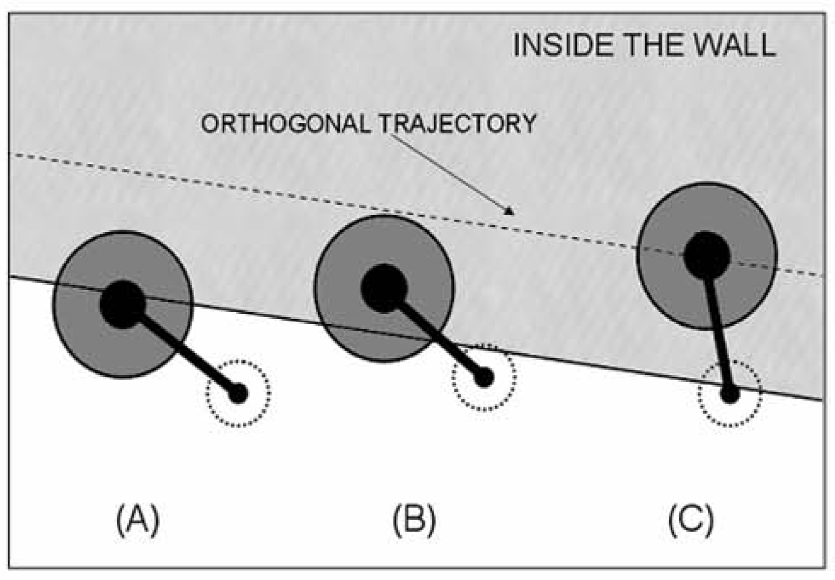
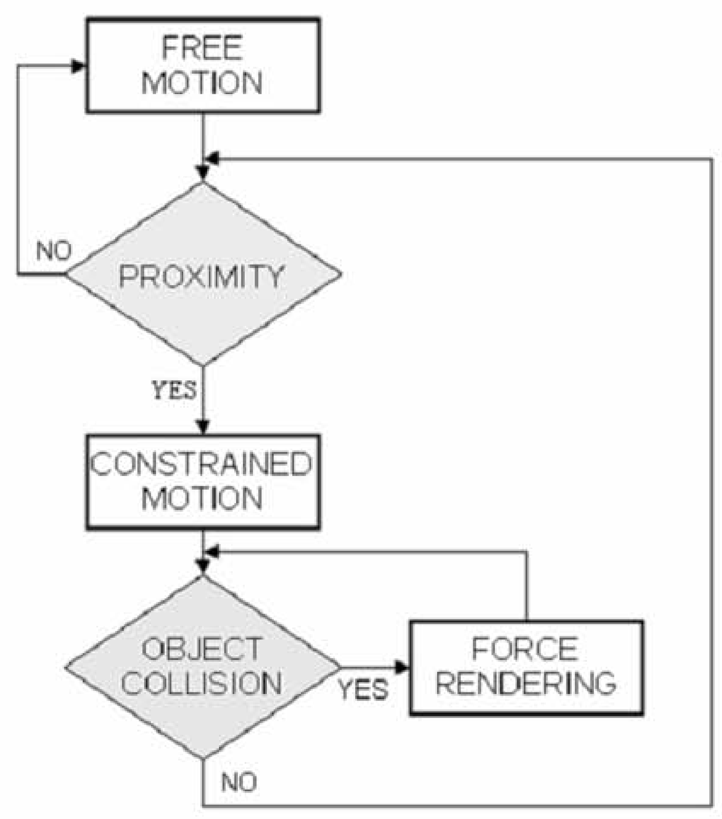
Using constrained motion, MP dynamics does not affect the rendered force F .

ALGORITHM IMPLEMENTATION

A switching strategy between free and constrained MP motion is required, in order to avoid undesiderable transients.

A **Proximity sphere** is built and centered at the haptic probe and a collision detection between the sphere and virtual objects is performed.





(A) No collisions: free MP motion

(B) Proximity collision: constrained MP motion. Forces are not yet rendered.

(C) Haptic collision: constrained MP motion. Forces are rendered by the haptic device.

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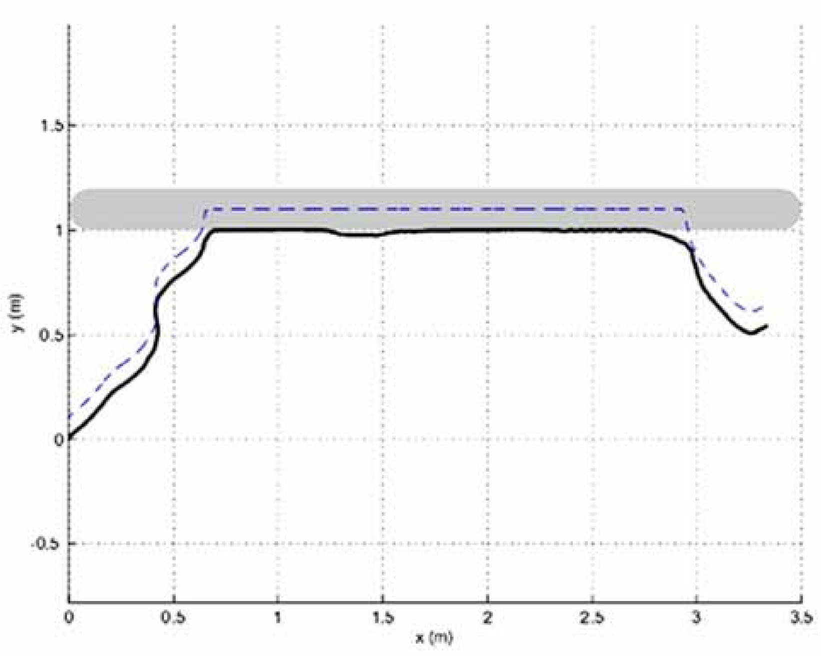
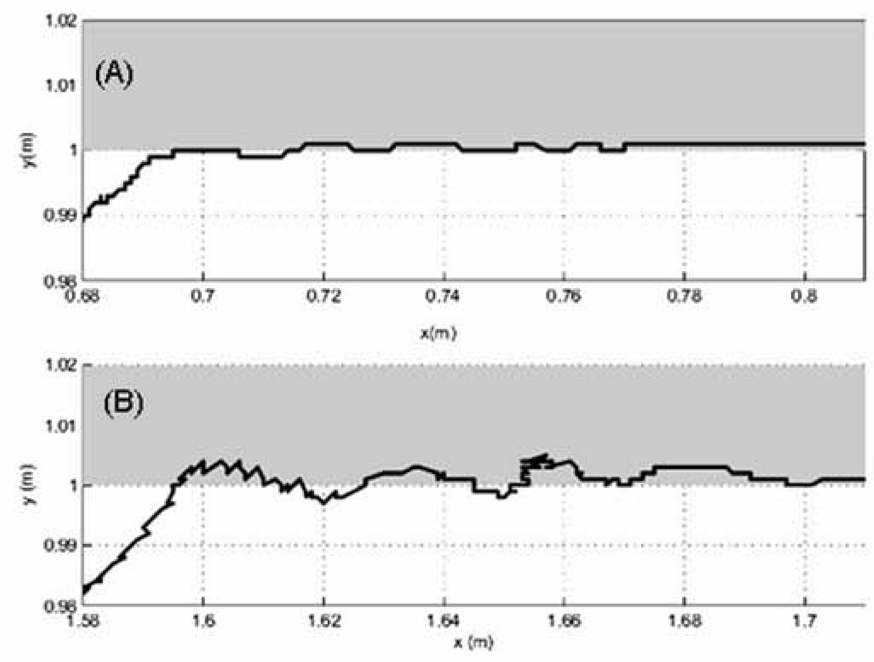
The force to be rendered by the MHI can be computed using common haptic rendering algorithms designed for grounded HDs.

EXPERIMENTS



Touching a virtual wall using the proposed algorithm (solid line: end-effector trajectory in the real world - dashed line: MP trajectory)



Comparing the same touch experiment with (A) or without (B) proximity collision detection.

FUTURE WORKS

•Extending the algorithm to the case of complex objects (friction, convex and concave surfaces…)

•Algorithms for virtual interaction with two or more MHIs within the same scenario

•Design and control strategies for a MHI able to grasp objects