Haptics-Augmented User Interaction

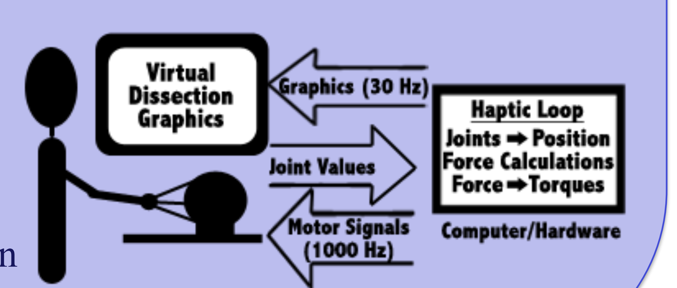
Introduction

Haptics uses the sense of touch to augment virtual simulations. The area has yet to be fully exploited and requires further research into methods of haptic rendering and creation of haptic simulations.

Haptic devices can provide a sensory or motor function: In its sensory role the user can learn about the environment such as in the case of virtual mechanisms.

In a motor role the haptic device can augment unwanted user motion during virtual simulations.

Application areas:
- Surgery
- Flight simulation
- Education
- Industrial manipulation



Haptics-Augmented Designs With Pre-computed Force Map

Motivation:
Haptic rates should exceed 1000 Hz for realistic feedback, thus calculations must be very short for immediate response. Without proper optimization geometric models can be too computationally intensive.

For small models it is possible to pre-computer a force map. Real-time control can be implemented with no new calculations.

Implementation:
Matlab and Simulink were used to interface with a Novint Falcon and to implement force generation.

Novint Falcon

Procedure

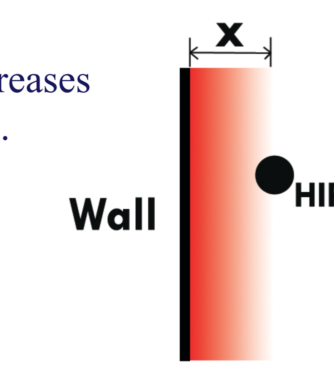
Initial:
- User inputs 2D design
- Computer generates force map

Run:
- Haptic device position mapped to force
- Force sent to haptic device

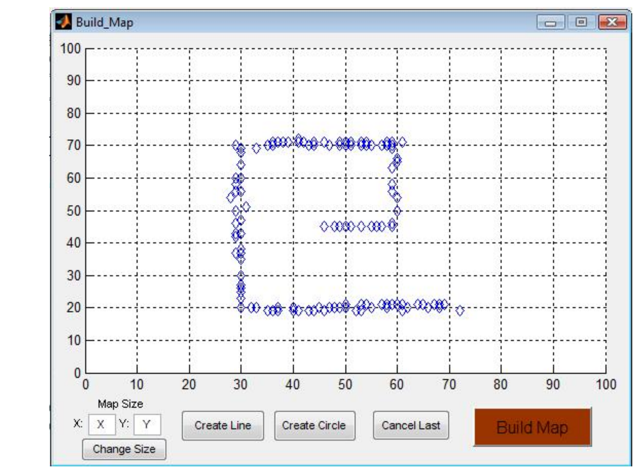
Rendering

Potential Fields Technique
Force is max at wall and decreases linearly as distance increases.

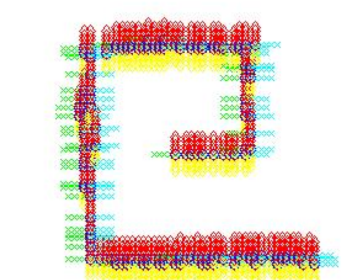
$F = F_{max} - k \bullet x$
F = Force
k = Constant
x = Distance



User Build Phase



Generated Force Map



Colors denote force direction

Haptic Rendering of Virtual Mechanisms

Motivation:
Visualization of the trajectory and inertial properties of mechanisms is unintuitive.

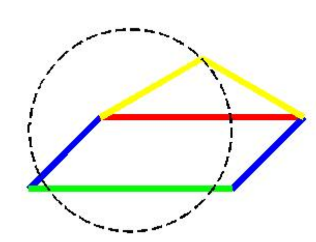
Traditional methods for learning about mechanism design is limited to calculations and visual representation.

Physical manipulation of mechanisms has a potential effect of increased the quality of student learning.

Implementation:
Matlab and Simulink were used to interface with the haptic device and graphical user interface.

SimMechanics was used to design the mechanisms and to provide virtual coupling to the haptic interface point.

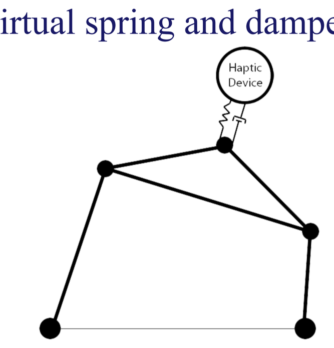
Example Trajectory



Parallelogram Fourbar

Feedback Design

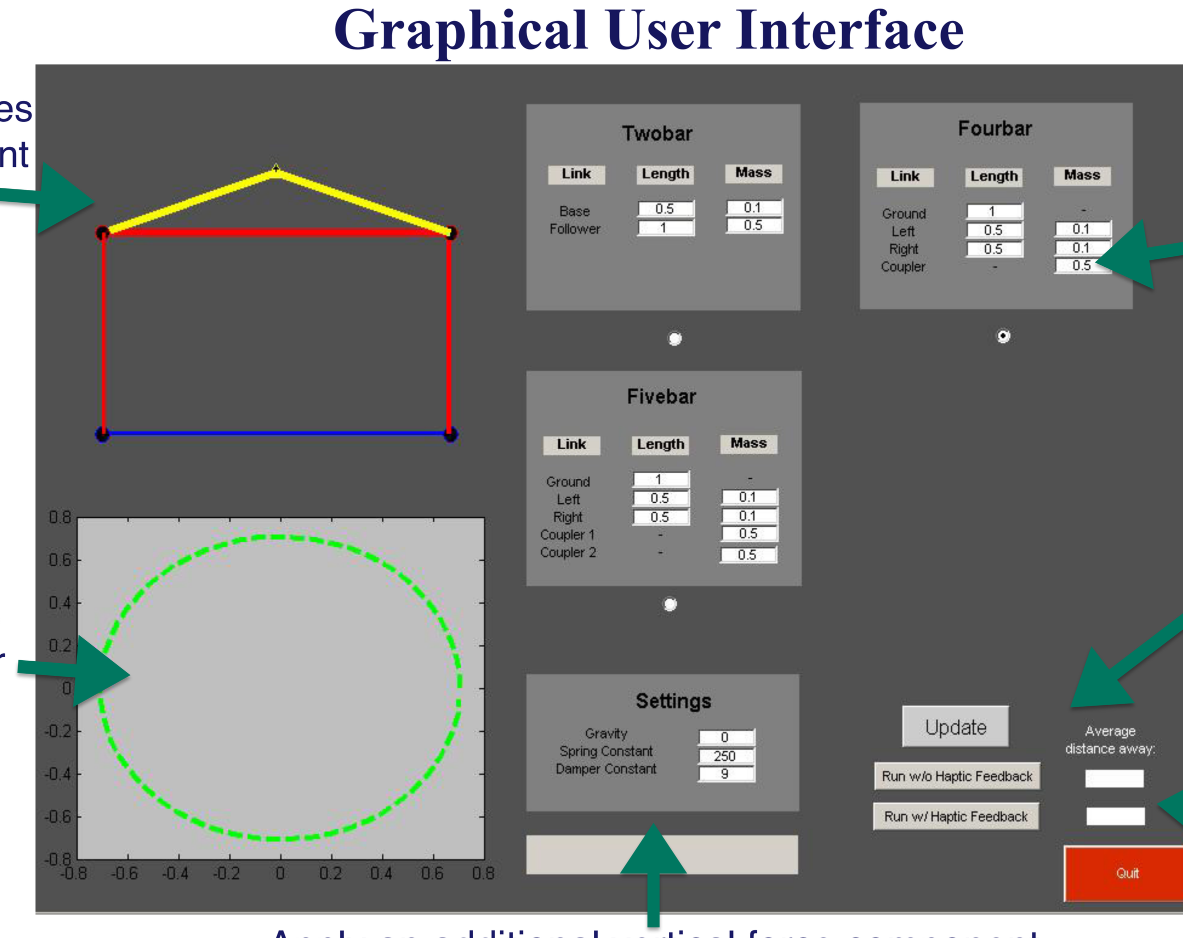
The haptic interface point is connected to the coupler by a virtual spring and damper.



Graphical User Interface

Diagram changes shape dependent on input parameters

Depicts user's trajectory after tracing the output



Choose two-, four-, or fivebar mechanism, link lengths, and individual masses

Trace trajectory of mechanism

Note the average error with and without feedback

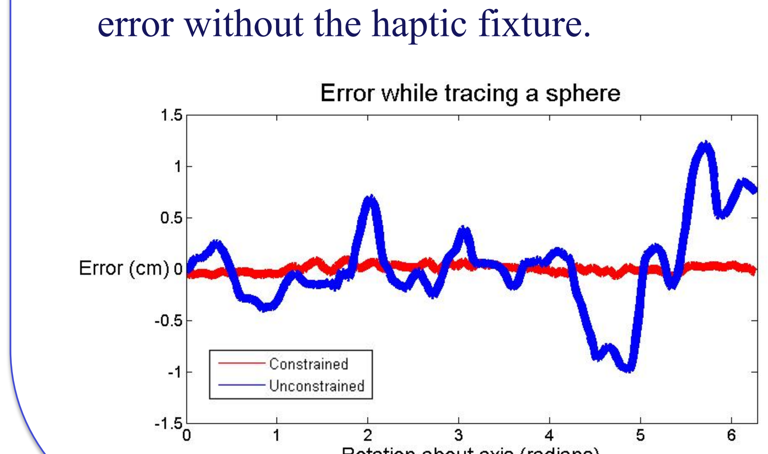
Apply an additional vertical force component or change spring-damper parameters

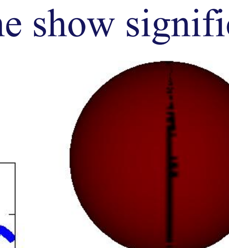
Virtual Fixture Example: Tracing a Sphere

Motivation: Straight and precise incisions are necessary for minimally invasive surgery.

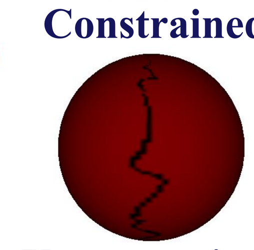
Task: User traces haptic device one revolution about a complex surface.

Results: Deviation about the central plane show significant error without the haptic fixture.





Constrained



Unconstrained

Haptic Simulation Training

Motivation:
Simulations require integrated visual and haptic feedback for realistic user interaction. It is often necessary to use 3D meshes in the form of CAD models or medical data for graphical representation.

Simulations should go beyond fundamental touch feedback; Additional force effects are necessary for involved training.

There is insufficient documentation for current haptic software to quickly teach new users.

Implementation

H3D, an open source haptics software, was used to facilitate graphical and haptic simulation.

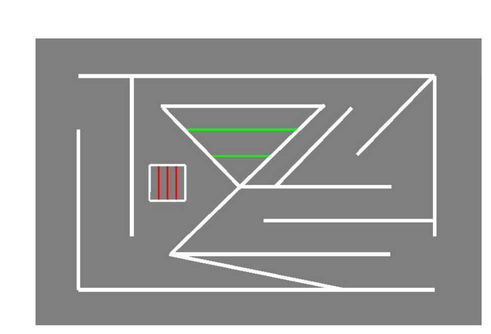
Force effects to constrain unwanted user motions were developed using Python to interface with the simulations.

Guides for designing simulations and demonstrations of particular force effects have been created.

X3D and 3DS Max were used to generate 3D Models.

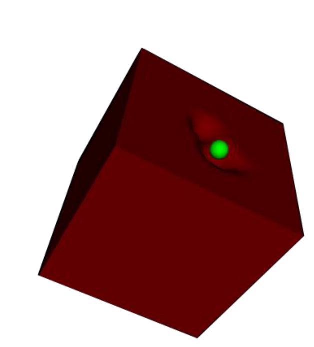
Phantom Omni

Demonstrations



Haptic Maze

- Human Mesh
- Pipe Traverse
- Needle Injection
- Planar Trace
- Block Deformation
- 2.5D Modeler
- Medical illustrations
- Haptic Maze



Block Deformation

Human Mesh

Future Work

Implementing new forms of force control for haptic simulations.

Development of advanced tutorials using C++.

Creation of robust surgical and biological simulations.

Integration of a 5 Degree of Freedom device within H3D for enhanced manipulability.

Acknowledgment

This project has been funded by a National Science Foundation Research Experience for Undergraduates and Zimmer Research Award.

Presenter: Colin Lea
colinlea@buffalo.edu
http://eng.buffalo.edu/~colinlea

Automation, Robotics, and Mechatronics (ARM) Lab

Advisor: Dr. Venkat Krovi
vkrovi@eng.buffalo.edu
http://eng.buffalo.edu/~vkrovi