Purdue Portable Haptic Display for Large Immersive Virtual Environments

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Overview

- The Purdue Portable Haptic Display is aimed at developing a platform-independent haptic rendering system that can be easily integrated into large immersive visual displays for multi-modal data perceptualization.
- Motivations
  - The Envision Center for Data Perceptualization at Purdue University has several kinds of large immersive visual displays including a CAVE™ and a tiled-wall display along with force-feedback haptic interfaces.
  - However, there exists significant incompatibility between both hardware and software of the haptic interfaces and the visual displays.
  - In order to facilitate the use of the haptic interfaces with the large visual displays, we have conceived the idea of a portable haptic display that has the architecture of distributed rendering through network.

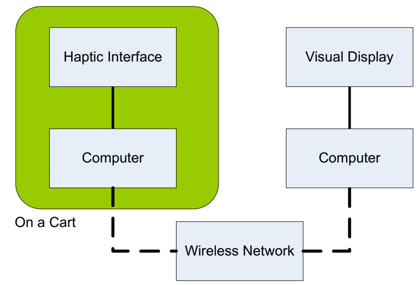

Fig. 1. Hardware structure of the Purdue Portable Haptic Display

Architecture

- Hardware (Fig. 1)
  - A haptic interface is mounted on a cart that contains a computer controlling the haptic interface, which provides convenient transportation to a visual display.
  - The computer takes care of haptic rendering and communicates with a computer (or a cluster of computers) operating a large visual display through network.
- Software (Fig. 2)
  - The haptics and graphics computers have their own model for virtual environments, and the models are synchronized during operation through network.
  - Each computer is in charge of rendering the virtual environment with the corresponding display.
- Advantages
  - The incompatibility issue is resolved, while the original setups of the haptic interfaces and the visual displays remain intact as much as possible.
  - The distributed nature of the rendering architecture significantly increases the computational power of the whole system.
  - The architecture is highly adaptable to a new display, environment model and software library; only model synchronizers need to be redesigned.
  - Therefore, the architecture allows platform-independence from virtually any haptic interface or visual display.

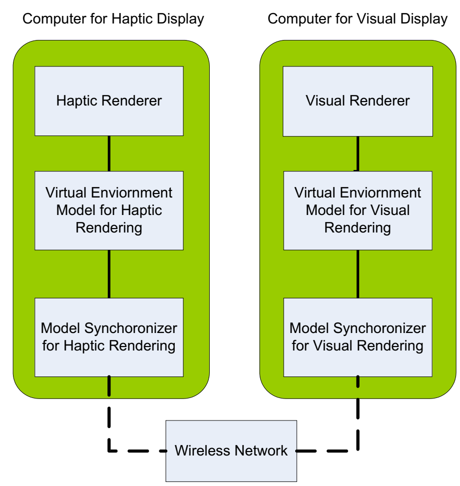

Fig. 2. Software architecture of the Purdue Portable Haptic Display

Current Progress

- The haptic renderer has been implemented using CHAI 3D (a open-source haptics library; www.chai3d.org) and supports the PHANToM family (Sensable Technology; www.sensable.com) and the Delta and Omega haptic devices (ForceDimension; www.forcedimension.com).
- Networking between the computers are achieved via TCP/IP.
- The visual renderer is also developed based on CHAI 3D, and can run on any computer with MS Windows as an operating system, including the CAVE™ and the tiled-wall display.
- Currently, the Purdue Portable Haptic Display can render fairly complex rigid virtual objects (both static and dynamic; see Fig. 3).

Fig. 3. A user feels a virtual can (with 43,539 vertices) displayed on a FLEX (CAVE™-like display from Fakespace Systems; www.fakesystems.com) using the Purdue Portable Haptic Display. The force-feedback device (Omega device) is controlled by a laptop mounted inside the cart. The laptop transmits visual information via wireless network to a computer (not shown) operating the FLEX.

Future Work

- The visual renderer will be replaced by one using VR Juggler (a device-independent open-source virtual reality suite; www.vrjuggler.org).
- The object model synchronizers will be upgraded to be capable of handling more complex virtual environment.
- The performance and limitations of the Purdue Portable Haptic Display will be carefully examined in terms of both engineering and perception.

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