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.

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.

Current Progress
- The haptic renderer has been implemented using CHAI 3D (a open-source haptics library; www.chai3d.org) and supports the PHANToM family (Sensible Technology; www.sensible.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).

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.

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

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

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.