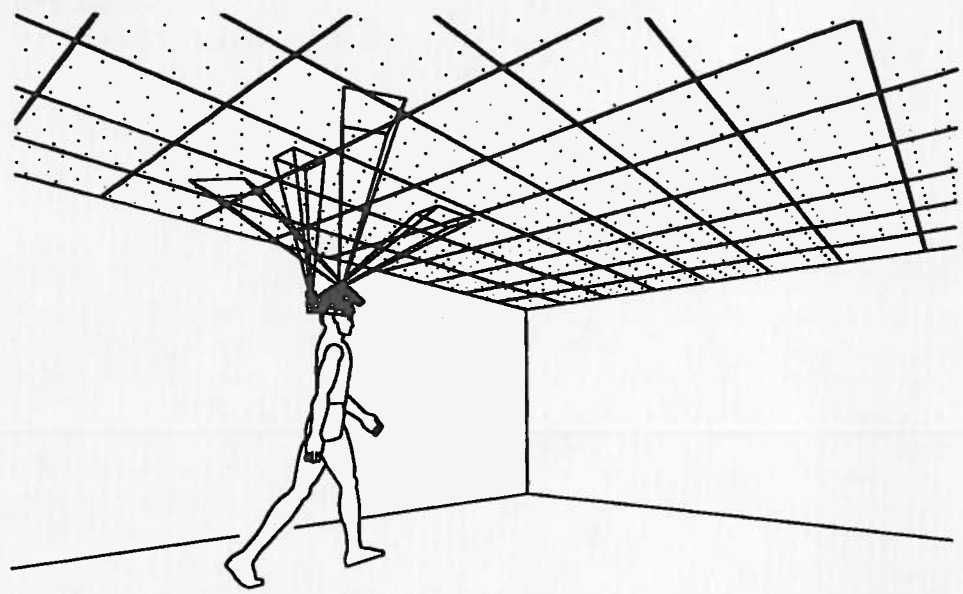
Head-Tracker Research

Navigation Technology for Head-Mounted Displays

Department of Computer Science
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599-3175
(919) 962-1758



Overview. Head-mounted displays and head-tracked stereoscopic displays provide the user with impressions of being immersed in a simulated three-dimensional environment. To achieve this effect, the computer must constantly receive information about the precise position and orientation of the user's head and must respond immediately to all changes in head position by adjusting the displayed image(s) appropriately.

The head-tracker project at the University of North Carolina at Chapel Hill investigates and develops methods for this position and orientation tracking. Our immediate goal is to develop optical head-tracking technology that will function within a room-sized environment and be accurate to within 1–2 mm and 0.1°. Longer-term goals include tracking within nonstructured environments. By non-structured environments we mean environments which are not modified to take into consideration the needs of the tracker—a regular room or the outdoors, for example.

Head Tracking at UNC. HMDs rely on three technologies: 1) a real-time graphics engine that generates a realistic image to each eye, 2) wearable displays and optics that present the image in front of the wearer's eyes, and 3) a sensor that measures head position. At UNC we are working on all three areas. One research group (Pixel-Planes) is dedicated to real-time computer graphics; another (HMD) designs HMDs and optics; and a third (Tracker) is developing tracker technology, which is described in this handout.

Magnetic trackers are the most widely used systems. They are small and unobtrusive, do not suffer from line-of-sight limitations, and recent models have high update rates and low latency. But HMD applications that merge the real and virtual worlds with see-through HMDs require accurate tracking across long distances to register objects properly in the virtual and the real worlds. Existing magnetic systems have limited range and give distorted readings because of the metallic materials in our environment, making it hard to align real and virtual objects.

Optoelectronic Tracker. We are working on an optoelectronic tracking system that overcomes these limitations. The system features infrared light-emitting diodes (LEDs) mounted in the ceiling of a room and imaging sensors, based on lateral-effect photodiodes, mounted on the head of HMD wearers within the room. The premise of the system is as follows: a HMD wearer's vantage point in the room is unknown, but the locations of the LEDs in the ceiling are known, and they can be used as navigation beacons. Clusters of image sensors located on each head measure the photocoordinates of multiple LEDs that are sequentially addressed and lighted. The result of lighting an LED is a spot of light on the image plane of one of the sensors on a given head. The 2D location of this light spot, or *photocoordinate*, is measured by a camera that employs a lateral-effect photodiode as an image plane. Given three photocoordinates measured with respect to the head's position and orientation and the corresponding location of the LED light sources in the room, both the position and the orientation of the head can be computed using a photogrammetric technique known as *space-resection by collinearity.*

A prototype of the optoelectronic tracker has been constructed that consists of a VPL EyePhone, 4 head-mounted Hamamatsu image sensors, and a 10- by 12-foot suspended ceiling made of standard 2- by 2-foot ceiling tiles with 32 infrared LEDs in each tile. The system can resolve linear motions of less than 2 mm and angular motions of less than .2° without the distortion seen in magnetic systems. Update rates depend on the number of LEDs imaged and the mode of operation. Under normal operating conditions, 3 or more sensors are aimed at the ceiling, 10–50 LED images are acquired, and the resultant update rate ranges from 30–100Hz, but 80+ Hz is typical. Lag is introduced by a two-stage

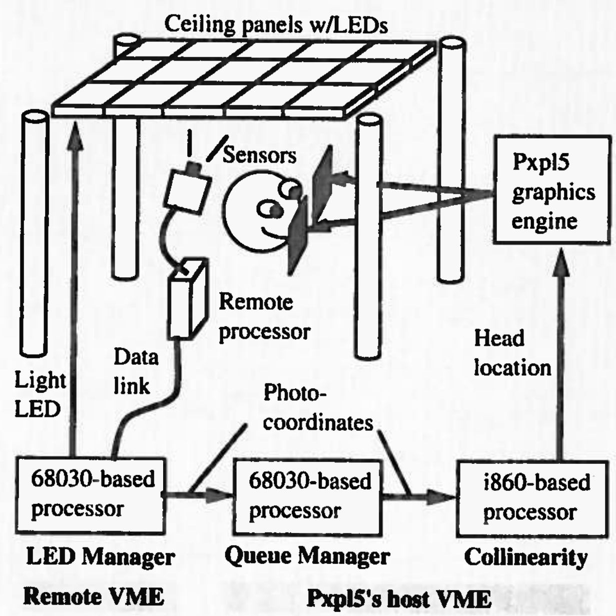


Diagram of Tracker System Dataflow