WorldCursor: Pointing in Intelligent Environments with a Tele-operated Laser Pointer

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ABSTRACT

We introduce the WorldCursor, a pointing device and cursor designed for intelligent environments. The WorldCursor is analogous to the mouse and cursor used in traditional GUIs: the user may select and interact with a physical device by positioning the cursor on the device and clicking. We use the XWand as a physical pointing mechanism, and couple it with the WorldCursor device which projects a cursor on the physical environment. The WorldCursor improves upon the XWand by removing the need for external positioning technology such as video cameras.

INTRODUCTION

In [1] we introduce the XWand, a hardware device and associated signal processing algorithms that controls multiple connected devices in a natural manner. For example, an XWand user may turn on a light in the room by pointing the wand at the light and pressing the button on the wand. Figure 1 shows the XWand prototype as demonstrated at UIST 2002.

The XWand system determines which device the user is pointing at by combining the orientation and 3-d position of the wand with a 3-d model of the room and the devices within it. Orientation of the wand is determined from onboard sensors, while wand position is determined with stereo computer vision. The 3-d model of the room and devices is entered into the system by pointing with the wand itself in a special training mode. With the orientation, position and model of the room, it is easy to determine which object in the world model the wand is pointing at, if any.

Users of the XWand are often impressed with the immediate and natural feel of absolute pointing. However, the pure geometry-based approach which enables absolute pointing also has a number of important drawbacks:

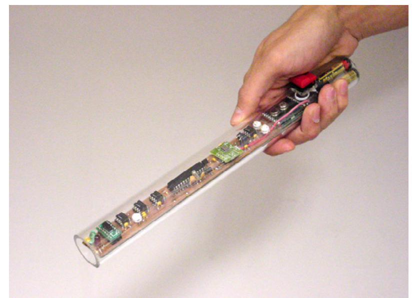

Figure 1: The XWand.

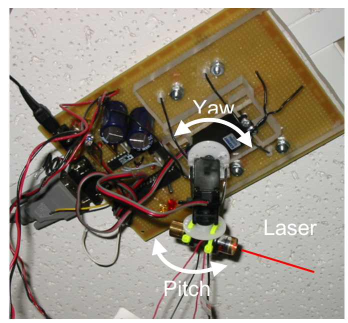

Figure 2: The WorldCursor device.

- Two or more cameras must be permanently mounted in the room. Besides the difficulty of installation, such cameras inevitably draw objections related to privacy.
- The cameras must be carefully calibrated to the room geometry upon installation, and recalibrated if they are moved.
- At least two cameras must have clear sight-lines to the wand at all times.
- The three dimensional position of each active device in the room must be known.
- Small errors in the orientation and position information translate to inaccuracy in pointing, possibly disrupting the interaction.

We set about exploring alternatives to absolute pointing, with the goal of eliminating the three dimensional positioning system. One general approach is to place tags in the environment, but they have drawbacks as well. By design tags require installation on every active device.

Active tags such as IR beacons, for example, require their own power, while passive tags such as RF ID tags only give proximity information over a limited range, and tags based on visual features rely on sophisticated onboard processing.

WORLD CURSOR CONCEPT

The WorldCursor system uses the XWand device but does not rely on a geometric model of pointing that requires the three dimensional position of the wand, nor on tags placed in the environment, nor on any external sensing in general. Instead, a laser spot projected on the environment gives the user feedback as to where the system believes the user is pointing, much in the same way that the cursor icon in WIMP interfaces provides feedback to indicate where the user is pointing with the mouse.

The WorldCursor system consists of a small tele-operated motion platform upon which is mounted a laser pointer. This device is controlled via a wired connection to a host computer, which is also connected to the XWand RF base station. The WorldCursor platform is programmed to follow the motion of the XWand, such that when the user points the XWand to the left, for example, the WorldCursor moves a corresponding amount to the left in real time. The user attends to the projected laser spot (the cursor) in the environment. By moving the XWand the user is then able to place the cursor on any object in the room, as they would place the Windows cursor on an onscreen object with the mouse. Because we only use the orientation information from the XWand, and not the XWand's 3-d position, we remove the original XWand system's requirement of the external computer vision system.

Interacting with active devices in the intelligent environment proceeds much as in the original XWand system. For example, to turn a household lamp on or off, instead of pointing directly at the lamp, the user moves the laser spot onto the lamp and clicks the wand button. The system determines that the cursor is on the lamp by comparing the current cursor position with the recorded cursor position associated with the lamp, collected beforehand. Note that this closed feedback loop is not accomplished by simply mounting a laser pointer on the wand itself.

XWand Device

The XWand hardware device contains onboard sensors including a 3-axis magnetometer and a 2-axis accelerometer to support the computation of orientation information and gesture recognition. The values from the accelerometer and magnetometer are relayed to a host computer by radio link. These values are combined to find the absolute orientation of the device with respect to the room. This orientation is updated in real time at a rate of about 50Hz, and is accurate to a few degrees in each of yaw, pitch and roll axes.

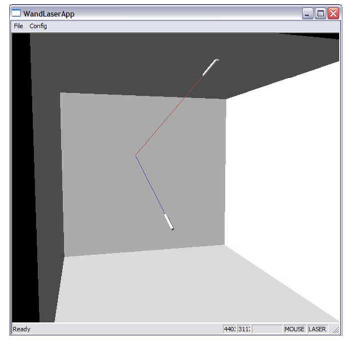

Figure 3: A visualization of the XWand (lower white cylinder) and WorldCursor device (upper white cylinder).

WorldCursor Device

The WorldCursor motion platform is mounted on the ceiling near the center of the room (see Figure 2). It consists of two high speed miniature servos of the type used on radio-controlled model airplanes, one mounted for yaw and a second for pitch control. Both servos are controlled by a PIC microcontroller, which takes yaw and pitch commands from the host computer via RS-232. The servos are each capable of moving over nearly a 170 degree range, at a speed of 333 degrees per second.

Mounted on the servo assembly is a red laser similar to those used in laser pointers. By controlling the servos, the platform is able to steer the laser spot to most points in the room below the ceiling, provided there exists a sight line to that point. Effective resolution in steering the laser is about 0.25 degrees or about one half inch at a distance of 9 feet. Figure 3 illustrates the configuration of the XWand and WorldCursor in a small room. Further details on the system, including issues related to control and world modeling, may be found in [2].

DEMO APPLICATIONS

We demonstrate the WorldCursor system in a number of home automation scenarios, including turning lights on and off remotely, controlling music playback, and Windows cursor control. The cursor control mode demonstrates the degree of precision of the WorldCursor system: the user merely brings the laser dot on the display. At the moment the laser dot crosses the bezel of the display, the laser dot is turned off and the Windows cursor is controlled, resulting in seamless integration of the tangible and the virtual. A video of the system is available at [3].

REFERENCES

1. Wilson, A. and S. Shafer. XWand: UI for Intelligent Environments, *in CHI 2003*.

2. Wilson, A. and H. Pham. Pointing in Intelligent Environments with the WorldCursor, *in INTERACT 2003*.

3. http://research.microsoft.com/~awilson.