Virtual Glassboat: For looking under the Ground

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ABSTRACT

A simple augmented reality system called the Virtual Glassboat is described in this paper. The Virtual Glassboat is a cart mounted computer display which scrolls with the movement of the cart. By pushing the cart over a floor or over the ground, a user can browse the underneath information such as gas or water piping work as if he/she were looking under the ground through the display.

1. INTRODUCTION

In many augmented reality (AR) systems, 3D position trackers or cameras are used to get the exact location of users and objects, and seethrough head mounted displays (HMD) are used to provide stereoscopic computer graphics. These devices are usually large, heavy, expensive, and very difficult to calibrate and register [1]. Even when only flat surfaces such as floors or walls are the target to augment the reality, 3D sensors or cameras are usually used to track the user's position.

In most AR applications that browse inside walls, floors or boxes, only 2D position detections and 2D information presentations are necessary. In our previous work [2], we have introduced a simple AR system called the Scroll Browser. This system reveals wiring and pipe-work inside walls on a hand-held display when the user traces the surface with a

Figure 1: The Virtual Glassboat system. The cart mounted display scrolls with the movement of the cart to provide the illusion that the user is looking underground.

2D position detector called a FieldMouse, which is a combination of a bar-code reader and a mechanical mouse. The Virtual Glassboat is an extension of the Scroll Browser to AR applications on floors or on the ground.

2. THE VIRTUAL GLASSBOAT

Figure 1 shows the Virtual Glassboat, a simple AR system that can be used to browse wiring or pipe-work under floors or under the ground. It is a cart-mounted computer system with a face-up display. The user can view graphical information on the display while pushing the cart over a floor or over the ground. The amount of movement and rotation is detected by the computer by monitoring the cart's wheels rotation. It is programmed to scroll out the display in the opposite direction to the movement of the cart. The system thus provides the illusion that the user is looking under the floor or ground through the display frame. The system derives its name from glass-bottom boats used at marine parks to observe creatures underwater.

3. IMPLEMENTATION

We have implemented the first prototype on a commercial cart that has four hard rubber wheels: two steering front wheels and two fixed rear wheels. The position and direction of the cart is detected by measuring the rotation of the fixed rear wheels. As shown in Figure 2, a reflection plate with 32 stripes is attached to each rear wheel (11.25 degrees

Figure 2: Underside view of the Virtual Glassboat. Optical sensors detect rotation of the rear wheels (left). The RFID reader

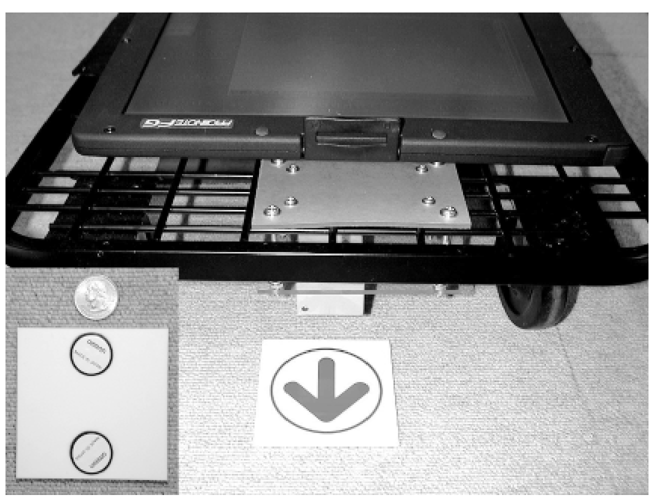

Figure 3: Position and direction of the cart are calibrated by reading the marker plate (center) inlaid with two RFID tags on the underside (left).

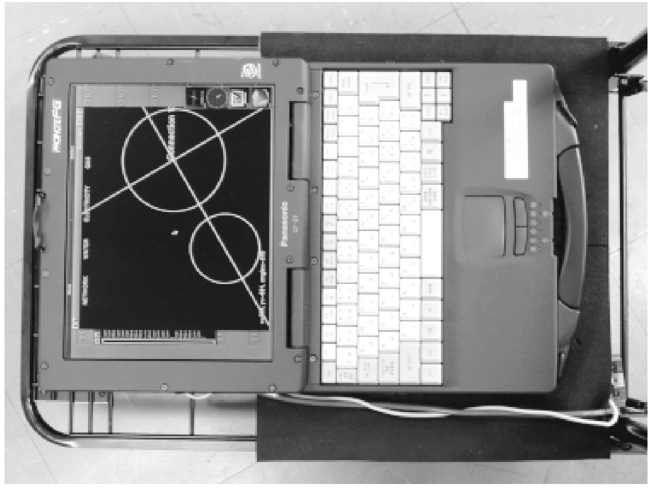

Figure 4: Drawing image is displayed and scrolled.

resolution) and photo interrupters are installed to measure the rotation. Electronic parts of a mouse are used to interface the photo interrupters with the note book computer on the cart.

In order to calibrate the absolute position and direction of the cart in the real-world, we have made a marker plate inlaid with two RFID (Radio Frequency Identification) tags on the underside and placed it on the floor (Figure 3). When the cart moves over the plate in the direction of the arrow on it, two tags are successively read by the RFID reader mounted on the front of the cart, and the position and direction of the cart are calibrated. In outdoor applications, longer-range RFID readers can be used to detect buried tags under the ground.

A browsing program developed by C language on Linux OS runs in the computer. This program scrolls out the PostScript

Figure 5: Test field (left) and the PostScript data (right) showing 23 manholes and rainwater/sewage pile lines under the field.

data on the display on the X Window, calculating the rotation and movement of the cart by reading the information provided by the photo interrupters and the RFID reader. Data that can be displayed as of now are PostScript files made of lines, circles, and letters (Figure 4).

4. APPLICATIONS

The current browser program which displays simple drawing images, can visualize underground piping, wiring and structure. It can therefore be used to locate underground objects to support maintenance or reconstruction work. As RFID inserted stakes have been developed, it will be possible to browse underground objects near the markers by using our system.

We have prepared underground pipeline PostScript data in front of our faculty building (Figure 5). Here is a sidewalk of about 100m x 20m, and there are 23 manholes and underground rainwater and sewage pipe lines. For each manhole, we have installed RFID tags which hold manhole ID number. By reading one of the manhole RFID and moves around the manhole by our system, we can identify and locate the underground pipes.

The Virtual Glassboat can also be used in an interactive art or museum system by displaying virtual objects. For example, we could use it as a virtual glass-bottom boat and chase virtual fish or take walks through coral reef on the floor. We can use it to display multimedia information on a museum floor on which large maps or diagrams are painted.

We have implemented the virtual glass-bottom boat application as shown in Figure 6. Fish animation is prepared on Macromedia Director on Windows 98 OS. Using the Director scripting language Lingo, the rotation and movement of the cart is calculated by reading the cart's photo interrupters which is connected to the mouse port. Fishes are programmed to cross the display randomly, and they are scrolled by the movement of the cart so that as if a user is chasing them. RFID reader is not used in this application. In the future version with fixed undersea object like seaweed, rocks, and corals, we should implement RFID tags on the floor.

5. EVALUATIONS

The direction accuracy when rotating the cart 360 degrees at one place was within 2%. The accuracy of the cart movement in straight lines of 1m to 5m was within 3%. Position detection error is accumulated by moving a long distance and by moving with complicated rotations. However, this result shows that our system has sufficient accuracy in actual application, in which the cart position is often calibrated by reading RFID tags.

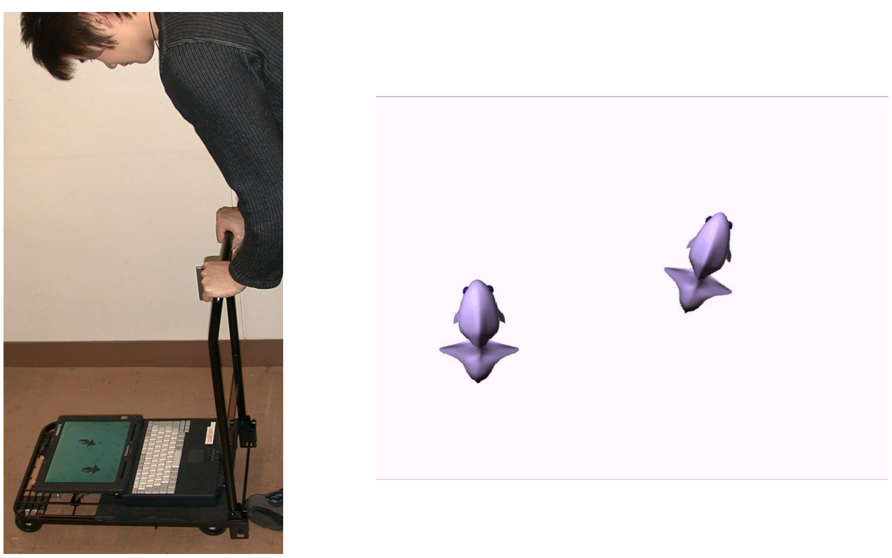

Figure 6: Chasing fish application (left) and fishes animation on screen (right).

Smoothness of the floor also affects the accuracy. Especially in the outdoor applications such as the underground piping search in Figure 5, the error increases when running over rough pavement. We regard the error arises by malfunction of the photo interrupters caused by rattling of the wheels. The rotation sensor should be improved for rough surface environment.

In case that the floor is flat, the current prototype provides sufficient augmented reality as if we were viewing information on a floor. Especially, in chasing fishes application in Figure 6, where precise positioning is not required, the system provides good and fun illusion.

6. RELATED WORK

As it is mentioned in the introduction, the Virtual Glassboat is an extension of our previous work called Scroll Browser [2].

There are many AR systems that enables to see-through inside a box and a wall. Many of them uses transparent HMDs [3]. In some systems, camera and hand-held display are used to achieve augmented reality [4]. Although the Virtual Glassboat system has no transparent feature, it realized enough augmented reality because of it's smaller view angle than HMDs.

Some AR systems are designed for outdoor use [5]. They require heavy DGPS equipment and calibration systems to operate. Although, the Virtual Glassboat has limitation of 2D display, and works only on flat ground, it operates simple inexpensive sensors.

REFERENCES

1. Azuma, R. T. A survey of augmented reality. In *Presence: Teleoperators and Virtual Environments*, 6(4), pp. 355–385, MIT Press, August 1997.

2. Siio, I., Masui, T., Fukuchi, K. Real-world Interaction using the FieldMouse In *CHI Letters, Vol.1, Issue 1 (Proceedings of the UIST'99)*, pp.113-119, ACM Press, November 1999.

3. S. Feiner, B. Macintyre and D. Seligmann , Knowledge-based augmented reality, *Communications of the ACM*, pp53-62, vol.36, No. 7, 1993.

4. Jun Rekimoto and Katashi Nagao. The world through computer:. In Proceedings of *the ACM Symposium on User Interface Software and Technology (UIST’95)*, pp. 29-36. ACM Press, November 1995.

5. S. Feiner, B. MacIntyre, T. Hollerer, and T. Webster, A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment. Proc. ISWC '97 (First Int. Symp. on Wearable Computers), October 13-14, 1997, Cambridge, MA.