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Tangible TableTop (TTT) Interface Based on Position/Orientation Measurement of Tags Using Photo Sensors and Accelerometers

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1 Introduction

We have developed a Tangible TableTop (TTT) interface to support remote collaborative works between an expert and multiple field workers in direct and intuitive way. For the 1st TTT [1], we employed a 3-D ultrasonic tagging system as physical 'tags' and proposed asymmetric bimanual interaction technique.

However, it is difficult to simplify the equipments since ultrasonic receivers have to be set up above the tabletop display. In addition, the measuring rate of each tag is not enough because of smoothing errors mainly caused by the multipath effect.

In this demonstration, we will present a novel method for measuring the position and orientation of physical tags (Fig. 1 (a)) on a tabletop display.

2 The Proposed Measureing Method

In the proposed method, we build two types of sensors in each tag for measuring the position and orientation with the complementary fusion. One is a set of photo sensors to observe fiducial marker patterns shown on the display. The other is a set of accelerometers to keep tracking the 3-D motion.

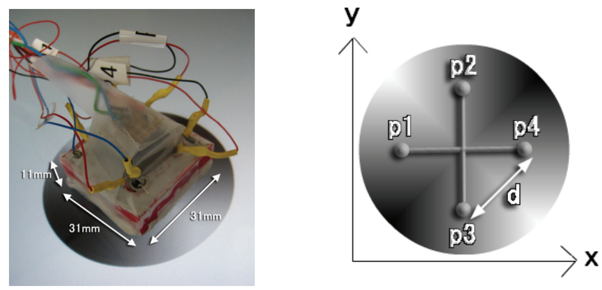
Basically, we measure the position/orientation of a tag using those photo sensors and a marker pattern on the display. Fig. 1 (b) shows a new circular marker pattern that can alleviate the influence of ambient light and unevenness of display luminance more than previously proposed in [2]. The new pattern also makes the size of tags 50% smaller.

The luminance gradates spatially and linearly so that output signals of photo sensors changes linearly as a tag moves on the marker pattern. So we can measure the position/orientation of a tag relative to the marker pattern by performing simple arithmetic operations using luminance measured at only four points.

This pattern enables us to measure the position/orientation of a tag precisely but limits the motion within a relatively narrow range up to half *d* in Fig. 1 (b) per frame. A rectangular marker pattern (Fig. 2 (a)) allows a tag to move in a wide range up to *w* in Fig. 2 (a) per frame by extending the size. So we can measure the position of a tag whenever a tag moves fast by using this pattern. However, luminance of this pattern gradates only in one direction in which *w* in Fig. 2 (a) stretches. Since we can measure the difference of position between a tag and marker pattern only in this direction, we need to steer the rectangular pattern in the direction where the tag is moving. We predict the direction using output signals of accelerometers and measurement results with a circular marker pattern just before using the rectangular pattern.

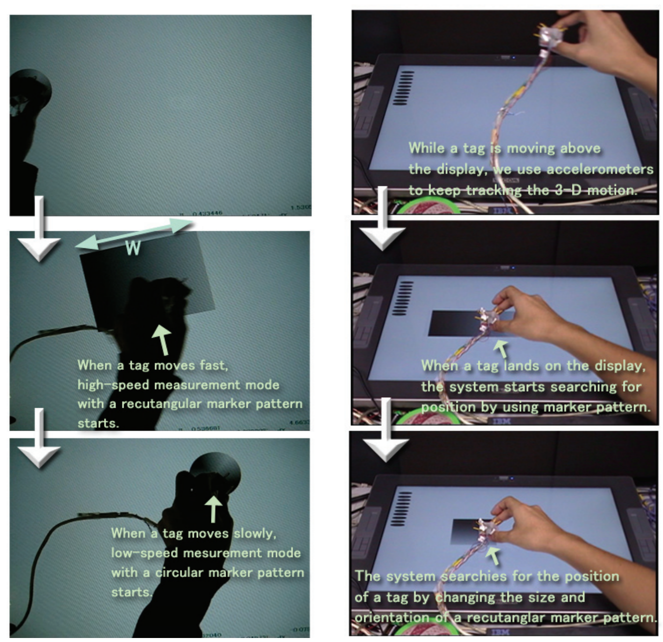
We can also use the rectangular patterns to search for the position of a tag in wide area on the display and to do an initial search by displaying this pattern sequentially shrinking and rotating it. While a tag is moving above the display, we use accelerometers to keep tracking the 3-D motion, and restart measuring the position/orientation after the tag lands on the display using photo sensors (Fig. 2 (b)).

We will demonstrate the 2nd TTT interface which employs this hybrid measurement method.



(a) (b)

Fig. 1. (a) A physical tag equipped with four photo sensors and three accelerometers. A gyroscope and a wireless communication device will also be implemented. (b) A new circular marker pattern. p1~p4 indicates home positions of four photo sensors of a tag.



(a)

Fig. 2. (a) Measuring position of a tag by switching two modes: low-speed measurement mode with a circular marker pattern and high-speed measurement mode with a rectangular marker pattern. (b) Measuring the position and orientation by using photo sensors after the tag lands on the display.

Reference:

[1] T. Kurata, et al., "Tangible Tabletop Interface for an Expert to Collaborate with Remote Field Workers", In Proc. CollabTech2005, pp.58-63.

[2] M. Inami, et al., SIGGRAPH 2005 Emerging Technologies, Augmented Coliseum: Display-Based Computing for Augmented Reality Inspiration Computing Robot.