Hybrid Indoor and Outdoor Tracking for Mobile 3D Mixed Reality

By Wayne Piekarski, Ben Avery, Bruce Thomas, and Pierre Malbezin

wayne@cs.unisa.edu.au, avery@tinmith.net, thomas@cs.unisa.edu.au, pierre@tinmith.net

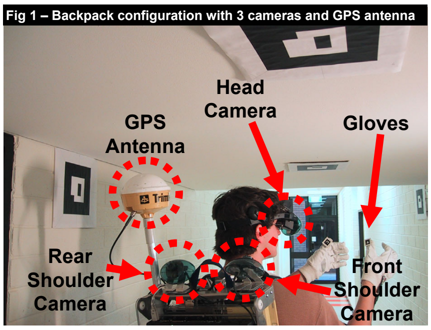
Wearable Computer Lab, University of South Australia

[WCL]

Introduction

This poster describes our hybrid tracking system that integrates standard outdoor augmented reality trackers with a low cost indoor tracker based on the use of fiducial markers and cameras. We use multiple cameras, separate orientation sensing, and scene graph integration to improve on similar previous systems. This hybrid tracker allows applications to operate within large indoor and outdoor environments with minimal hardware scaling costs. Tracking of the head and hands is performed using world coordinates both indoors and outdoors, and has been integrated into our existing Tinmith-Metro mobile 3D modelling application.

Fig 1 – Backpack configuration with 3 cameras and GPS antenna



Mobile Hardware

To perform this research, the Tinmith-Endeavour mobile backpack was used (see fig 1, 2, and 3). When used outdoors, we use typical outdoor AR tracking devices. Position tracking of the body is performed using a Trimble Ag132 (50 cm) GPS receiver. The orientation of the head is measured using an InterSense IS-300 hybrid sensor.

A forward looking firewire video camera mounted on the head provides the AR overlay as well as the tracking of fiducial markers on the hands. The hand tracking is useful for building AR applications where the user needs to interact with the 3D objects in the environment directly (see fig 3). Two upward looking firewire video cameras are added to support the indoor tracking system, which uses fiducial markers placed on the ceiling and upper walls of each room.

Fig 2 – Switching from outdoor GPS to indoor marker tracking

Indoor Tracking

ARToolKit fiducial markers 20 cm x 20 cm in size are placed approximately 2.5 metres apart on or near the ceiling (see fig 4). Marker patterns are reused between rooms to minimise processor usage, and markers on the doors switch between rooms. The patterns used are based on a 4x4 grid pattern optimised for use with the 16x16 ARToolKit sample grid. The markers are modelled as part of the Tinmith-evo5 scene graph (see fig 5) in the room's coordinates.

The two shoulder cameras are elevated at 45 degrees to ensure that close markers are within 1-3 metres and the field of view, and at the most accurate orientations. Even with 2.5 metre marker spacing, a single camera still does not typically have a marker within view, so two shoulder cameras as well as the forward looking camera are used to increase the probability of tracking. Using the scene graph model, the software can compute the relative locations of the cameras to the markers, and therefore in world coordinates. Using a model of the user's body also in the scene graph (see fig 6), the position of the user's torso centroid is estimated by each camera tracking a marker. These positions are averaged together to produce the final estimate of the user's position. The orientation is always generated by the IS-300 since the results are smoother and more accurate than ARToolKit.

Fig 3 – Gloves used to manipulate 3D objects at a distance

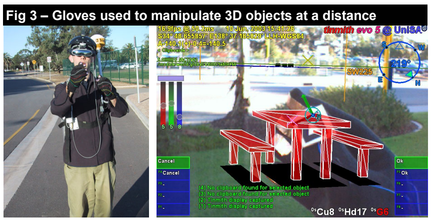


Fig 4 – Generated markers placed on the ceiling of a typical room

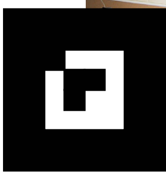


Fig 5 – 3D scene graph representation of the markers and rooms

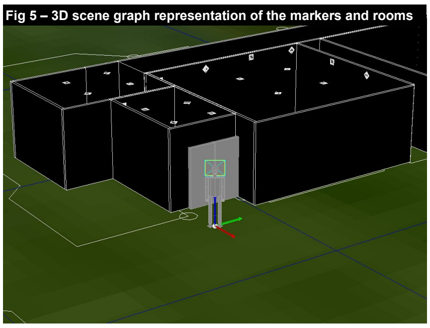
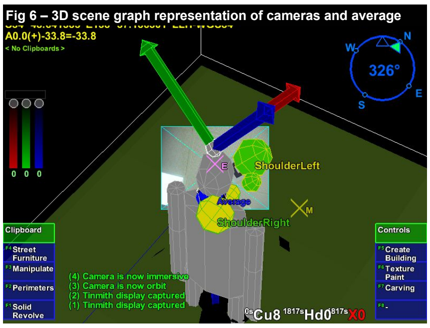


Fig 6 – 3D scene graph representation of cameras and average



Filtering and Results

The indoor and outdoor trackers are combined using a Tinmith-evo5 filter object that passes on the newest tracker data to the rest of the system. The scene graph abstracts away the complex transformations required to model the environment and simplifies development. Since all tracking is performed in world coordinates, applications do not need to know the source of the data.

We performed some informal experiments to evaluate the performance of the indoor tracker. When used to track the head indoors, typical errors were between 10 to 20 centimetres in each axis. With multiple tracking solutions this accuracy improves but this is difficult to measure and model accurately. When operating outdoors, the accuracy is limited by the position and orientation sensors in use. The hand tracker performance is consistent across both indoor and outdoor domains and provides a cursor that is always within the fiducial markers on the thumbs.

Some current problems to solve are dealing with the gap in the transition from outdoor to indoor, false marker detection, varying lighting conditions, and achieving continuous tracking of at least one marker at all times.

Fig 7 – Results from informal experiments for a single camera tracking a single fiducial marker

	X (east)	Y (north)	Z (height)
Average	9.8 cm	10.2 cm	19.7 cm
Minimum	1.0 cm	4.5 cm	15.5 cm
Maximum	17.5 cm	19.0 cm	24.0 cm

More Info at http://www.tinmith.net and http://wearables.unisa.edu.au

Please visit the Tinmith and Wearable Computer Lab web sites to find out more information about this project, as well as other interesting projects currently in progress.

UniSA