Wide-Area Tracking Tools for Augmented Reality

Joseph Newman[1], Gerhard Schall[1], István Barakonyi[1], Andreas Schürzinger[2], Dieter Schmalstieg[1]

[1]Graz University of Technology, Institute of Computer Graphics and Vision, Inffeldgasse 16a, A-8010 Graz, Austria
{newman,schall,bara,schmalstieg}@icg.tu-graz.ac.at
[2] Ubisense Ltd., Lise-Meitner Str. 10, 64293 Darmstadt, Germany
andreas.schuerzinger@ubisense.net

Abstract. We have developed a hand-held augmented reality platform exploiting a combination of multiple sensors built around an ultra-wideband tracking system. We demonstrate two applications illustrating how an environment exploiting this platform can be set up. Firstly, a technician-support application provides intuitive in-situ instructions on how a wide area tracking system should be configured. The use of 3D registered graphics greatly assists in the debugging of common awkward use cases involving reflections off metal surfaces. Secondly, a navigation application utilises this newly configured and calibrated tracker, as well as other sensors, adapting to whatever is available in a given locale.

1 Introduction and Motivation

Although the so-called "Smart Building" has been a dream of architects, engineers and social anthropologists alike, thus far it has proved necessary to take existing "dumb buildings" and attempt to install the necessary sensors in order to retrofit some sort of sentient behaviour. Wide-area tracking systems such as those based on ultrasound or ultra-wideband (UWB) electromagnetic signals are promising solutions to the problem of affordable, accurate and widespread sensing of location, which is a powerful source of context. However, they are limited by the reflective properties of many modern building materials. Consequently, careful configuration, calibration and ongoing maintenance by experienced technicians are often necessary. One such COTS system has been developed by Ubisense [5] using UWB short duration pulses emitted by an active tag (Ubitag) user-worn or device-mounted. The use of both time-difference-of-arrival (TDOA) and angle-of-arrival (AOA) techniques for position calculation in the wall-mounted sensors (Ubisensors) makes it possible to locate a tag within 15cm in three dimensions.

Augmented Reality (AR) superimposes registered 3D graphics over the user's view of the real world, allowing a user to share the computer's perception of the environment [1]. When the environmental model is misconfigured, then AR is often the only medium within which sense can be made of the data. Early work on mobile AR used bulky backpack prototypes [2]. However, there is a recent trend towards smaller, discreet, lightweight hand-held setups that are much more socially acceptable in environments in which PDAs and smartphones are already commonplace. We have built a prototype hand-held system, consisting of a Sony VAIO U70 and a variety of different sensors attached to an acrylic mount (see Figs 1 and 2). The sensors consist of a USB camera serving the dual purpose of providing images for an optical tracking system and also for providing the video required by the magic lens metaphor; a Ubitag, providing position estimates only; and an Intersense InertiaCube3 inertial tracker providing orientation estimates only. The latter two sensors are highly complementary as, when aggregated, they provide the full six degrees of freedom necessary for tracking rigid bodies.

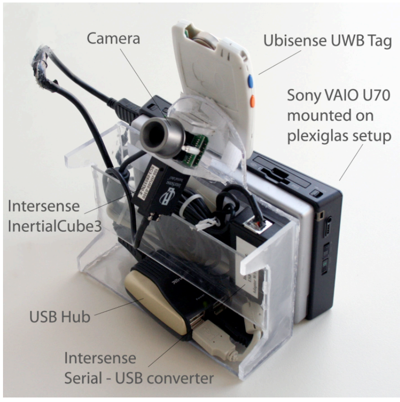

Fig. 1. Back view of handheld AR platform

Fig. 2. Front view of handheld AR platform

2 Technician Support

The technician support application aims to bootstrap the process of building components of a Ubicomp environment, from within that environment itself. Ubisensors and Ubitags are themselves tracked using fiducial [4] markers (see Fig. 3). The AOA bearing measurements made by the Ubisensors can be directly compared with those measured determined by visual tracking, and the information overlaid in the user's view. In this way, the accuracy of bearing estimates, signal strength and reflected signals can easily be analysed hands-free in an intuitive context. The visualisation of sensor measurements has proven to be particularly useful in problematic situations involving multipath signals caused by reflections from large metallic surfaces(see Fig. 4). Our system also aids technicians in the design of baffles that can block such undesirable signal paths.

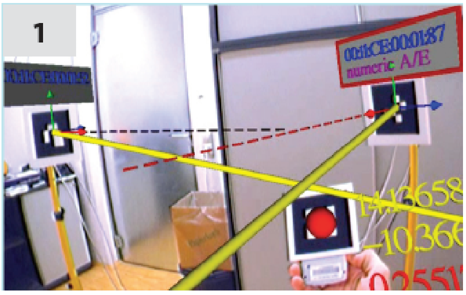

Fig. 3. Intersection of the bearings from the Ubisensors, identified by MAC address, demonstrate the claimed 10-15 cm accuracy of the Ubisense system. The measured bearing and accuracy metric numerically augment the Ubitag itself.

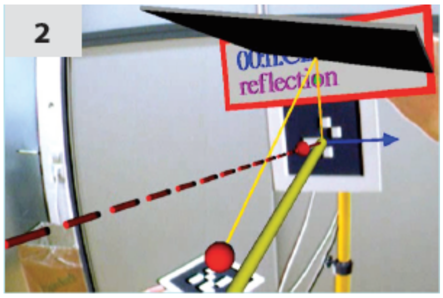

Fig. 4. Visualising problematic multipath signals caused by reflections from large plane metallic surfaces close to a Ubisensor.

3 Indoor Navigation

Previous experiments with indoor navigation systems relied solely on widely distributed fiducial markers to provide a wide-area vision-based tracking capability of moderate accuracy. New tracking technologies, such as Ubisense's, robustly cover large areas without the visual clutter of visual markers, or the brittleness associated with natural-feature based vision trackers. This motivation lead us to explore how a wide-area tracker, that can only sense position, lends itself to a hybrid approach whereby it is combined with complementary sensors to yield the pose estimates required for augmenting a user's view.

A dynamically reconfigurable version of the OpenTracker [3] tracking middleware ensures that the pipes-and-filters network connecting producers and consumers of tracking information continuously adapts such that pose estimates are always available. For example, when a fiducial marker is visible then pose is taken directly from the vision algorithms; however, when moving into an area where fiducials are either no longer present or are not visible due to occlusion, then the positional component of pose is taken from the Ubisense system and the orientational component of pose is taken from the inertial tracker.

A real Ubicomp environment, its size notwithstanding, will be richly populated with objects both static and dynamic. Although originally designed for a large area requiring navigation cues, the system is still sufficiently flexible to visualise all these elements. Figures 5 and 6 show the navigation system in action, with navigational cues, state information and current location visible using a "World in minature" view.

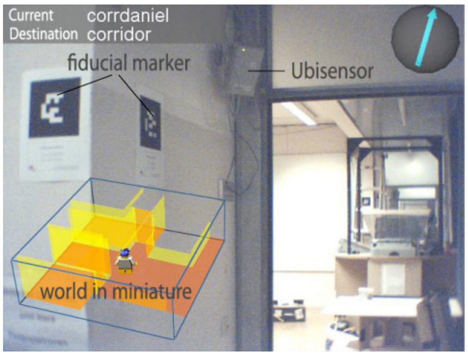

Fig. 5. Navigating towards destination "corridor". Location can be determined from Ubisense wide-area tracker together with observations of fiducial markers. Necessary direction of travel indicated by compass pointer in top-right.

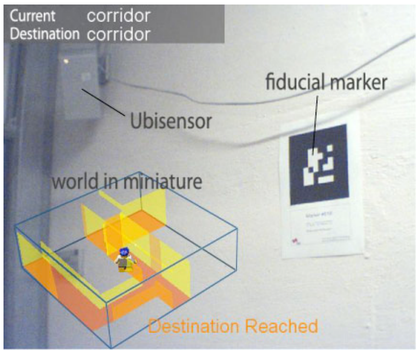

Fig. 6. Navigation to destination "corridor" completed. Full range of sensors, including fiducial markers and Ubisense wide-area tracker are utilised.

4 Conclusion

We have implemented two different Augmented Reality applications that interact with the sensors in the environment in distinctive ways. A technician support application can be used to configure a wide-area tracker, whilst the navigation example shows how an application can use this wide-area tracker and other sensors to adapt to meet the needs of an application in very different settings using the resources to hand.

References

1. Kasim Rehman, Frank Stajano, George Coulouris: Visually Interactive Location-Aware Computing. Ubicomp 2005: 177-194
2. Hallaway D., Höllerer T., Feiner S., Bridging the gaps: Hybrid tracking for adaptive mobile augmented reality in Applied Artificial Intelligence, Special Edition on Artificial Intell gence in Mobile Systems, 25(5), July 2004.
3. Reitmayr, G., Schmalstieg, D., An Open Software Architecture for Virtual Reality Interaction Proc. VRST'01, Banff, Canada, Nov. 15 - 17, 2001.
4. H. Kato and M. Billinghurst. Marker tracking and hmd calibration for a video-based augmented reality conferenencing system. In Proceedings of the 2nd IEEE and ACM International Workshop on Augmented Reality (IWAR'99), San Francisco. IEEE, October 1999.
5. P. Steggles and S. Gschwind, The Ubisense Smart Space Platform, Advances in Pervasive-Computing, Adjunct Proceedings of the Third International Conference on Pervasive Computing. Vol. 191, 2005