Instant Replay using High Speed Motion Capture and Projected Overlay

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Abstract

We describe the interactive demonstration 'Instant Replay' to be shown at the Emerging Technologies at Siggraph 2006. Instant Replay is an example application of an inexpensive, highly accurate 'motion capture' system that is able to effectively track many fast-moving, rotating objects. The system works at very high frame rates (500Hz), and reduces cost by employing relatively simple LED projector components in place of high-speed cameras. The cost of the system is only a few hundred dollars.

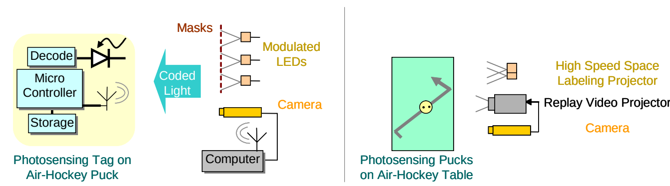

Figure 1: (Left) The interaction of photosensing tag with space-labeling beamers. (Right) The setup for our demonstration. The camera captures live action and the photosensors on air-hockey puck record motion at 500 Hz. The trajectory (and slower frame rate video) is played back at 10x slow speed by the projector.

1 Introduction

The core technical innovation of this work is the system's space-labeling technology. An array of inexpensive, solid-state, high-speed LED devices that project 10,000 invisible (infrared) patterns into the space every second. Any number of photo-sensing tags within the space detect these patterns and are thereby able to determine their own locations. Since the entire space is "labeled," the speed of the system remains constant regardless of the number of tags being tracked. The tags use very inexpensive, off-the-shelf IR-decoding modules and micro-controllers. A disadvantage of our approach is that the tags must be in the line of sight of the transmitters (at least those that label the space it occupies). Furthermore, we face the usual challenges of dealing with limited dynamic range when the ambient lighting is very strong and dealing with loss of communication due to occlusions (shadows).

2 High Speed Tracking

Let us consider other optical location tracking with markers. Motion capture systems used in movie studios commonly employ high-speed cameras to observe passive visible markers or active light emitting diode (LEDs) markers. But the bandwidth limits the resolution as well as the frame-rate. To robustly segment the markers from the background, these systems also use methods for increasing marker contrast. This usually involves requiring the actor to wear dark clothes in a controlled lighting situation. In our case, the use of photosensing allows capture in natural settings. Since the photosensors are barely discernible, the character can wear natural clothing with the photosensing element of the tag poking out of the clothing. The ambient lighting can also be natural or theatrical because the photosensors receive well-powered and modulated IR light.

Recently, [Raskar et al. 2004] [Nii et al. 2005] have presented the idea of locating photosensing tags with a traditional data projector. By limiting ourselves to a speci£c goal, we are able to use a more common light source – an LED – making our system scalable, versatile, compact, and inexpensive.

3 Implementation

The transmitter is a light emitting diode (LED) with a passive £lm set in front and temporally modulated at 455 kHz. The tag can decode binary data from an LED in a given time slot by tuning into the 455 kHz carrier signal. The binary £lm achieves £xed spatial modulation–the optical signal is transmitted in parts where the £lm is transparent and blocked where the £lm is opaque. The receiver decodes presence or absence of modulated light in a given time slot with synchronization. The transmitters run in an open loop. The tag stores the decoded data in onboard ¤ash memory or transmits via the optional RF channel. A camera is used in the system to a get a visual representation of the scene. However, the camera is not used in location tracking.

We will demonstrate the new space-labeling projector technology within a fast-paced, engaging, high impact setting that presents multiple challenges to system throughput and component wear.

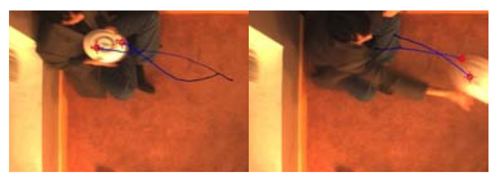

Figure 2: The Frisbee is tracked at 500 Hz with trails indicating locations within a camera frame.

References

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RASKAR, R., BEARDSLEY, P., VAN BAAR, J., WANG, Y., DIETZ, P., LEE, J., LEIGH, D., AND WILLWACHER, T. 2004. RFIG lamps: Interacting with a Self-describing World via Photosensing Wireless Tags and Projectors. In *SIGGRAPH, ACM Transactions on Graphics*, vol. 23, 406–415.

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