Tracking the Wiimote in 3D using ARToolkit

Raphael Wimmer, Sebastian Boring, Johannes Müller

University of Munich
Amalienstr. 17, 80333 Munich, Germany
{raphael.wimmer, sebastian.boring}@ifi.lmu.de, muellerr@cip.ifi.lmu.de

Abstract: Since its introduction in 2006, Nintendo's Wii remote game controller (wiimote) has been used in many research projects. Most of the time however, only its accelerometer data is actually used. We present a system that allows 3D tracking of the wiimote using its built-in camera, active IR markers and a modified ARToolkit library. Multiple markers are then discriminated by their blinking patterns. We conclude on using accelerometers to supplement optical tracking.

1 Introduction and Related Work

In instrumented environments different interaction modalities are supported, such as interactive, direct-touch displays and tangible interaction. While these can facilitate many interactions in such environments, both have their drawbacks. Direct-touch displays require users to physically reach the desired interaction area [R97]. If the data is distributed on multiple displays, users have to move back and forth between them, which leads to a decreasing interaction speed. Tangible interfaces on the other hand usually allow remote interaction with the displays in the environment. If they are used as pure remote controls, they naturally lack a direct mapping between input and output. This can be overcome by directly attaching the tangible interface to a display [HBB07]. While this is suitable on horizontal displays, it is not feasible on vertical ones. For this, a tangible, direct pointing device enables comfortable remote interaction with multiple displays while providing a mapping between input and output device. The research conducted on tangible pointing devices was mostly focused on technical implementation. While the *BlueWand* [FKO03] system does not offer absolute 3D tracking through the built-in gyroscopes and accelerometers, the *XWand* [WS03] system utilizes a digital compass as well as two IR LEDs that can be tracked by multiple cameras. In this paper, we describe the use of the wiimote for interacting across multiple displays.

2 3D Tracking with IR Markers

The main goal of our research is to track the wiimote's position and orientation in an instrumented environment that comprises four large displays (three wall displays and a tabletop). As the displays need to be distinguishable, each of them needs to be equipped with a certain number of IR markers for tracking and identifying them. We will describe the fundamentals of visual 3D tracking, followed by an introduction to our marker setup.

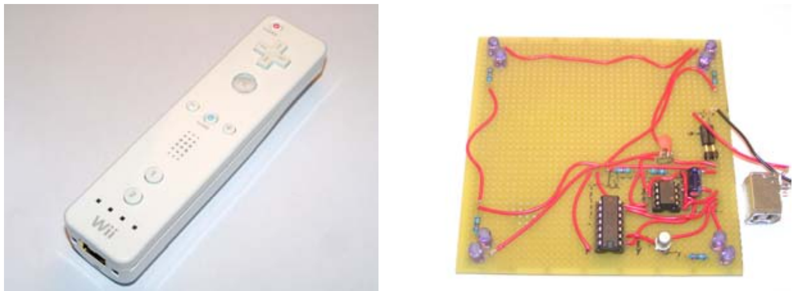

Figure 1. Left: Nintendo's Wii Remote game controller. Right: An active IR marker with four pairs of IR LEDs (120 mm x 120 mm). One pair of LEDs is driven by a 555 timer IC. The duty cycle of the LEDs encodes the marker ID. The marker is powered over USB or by a small battery.

2.1 Fundamentals of Visual 3D Tracking

Calculating a 3D position and orientation of a marker with four tracked points has been done before. One widely known library is the *ARToolkit* [KBP+00] which provides functions to allow real-time 3D tracking of fiducial markers. The concept of detecting the square-shaped markers (i.e. finding edges, calculating corner points, transformation into a planar square, comparison to pre-defined markers) has been partly adopted in this work. With our setup, the corner points are already given through detecting the four IR LEDs of an IR marker (see Figure 1).

2.2 Discriminating IR Markers

In contrast to ARToolkit, our system cannot use a distinctive pattern in the middle of the marker due to the limited detection capabilities of the wiimote's IR sensor (four points detectable). In order to distinguish two different IR markers we used a different blinking scheme of the marker's IR LEDs. To provide robust tracking, we only use one of the four marker LEDs for identification whereas the remaining three LEDs are illuminated constantly throughout the entire interaction.

The marker's ID is encoded in the duty cycle of the LED, i.e. its on/off ratio. This naturally reduces the detection ratio as our system has to compare several frames in order to identify a marker. However, this reduction is not crucial for real-time applications as it still allows a detection ratio of more than 10 Hz. Another limiting factor is the size of the marker as it affects on the detection range. The wiimote needs to capture all the four corner points at the same time. If the marker is designed too big, the wiimote needs to be far away (angle of aperture: 42 degrees), whereas if the markers are too small, two different LEDs appear as one LED to the wiimote. The features and limitations will be discussed in the next section.

2.3 Features and Limitations

We have built a proof-of-concept implementation of the described prototype. Based on several practical tests, we discovered an adequate size of 80 mm x 80 mm of the markers (Minimum range: 0.14 m; Maximum range: 4.0 m). Currently, our prototype uses two IR markers (duty cycles 33% and 66% respectively) where the marker recognition happens within a maximum of 112 ms. Depending on the detected marker, a certain 3D object is shown in on the screen to demonstrate discrimination and tracking of the markers.

3 Conclusions and Future Work

We have presented a system allowing full 3D tracking of the wiimote in an instrumented environment. By leveraging ARToolkit's 3D tracking algorithms, our system provides robust detection of the wiimote's position and orientation. Through our discriminative markers, a user can "pick up" objects from a certain, distant display and transfer them to another one. With the additional usage of the wiimote's sensors, systems like *Synchronous Gestures* [H03] are realizable between the wiimote and a user's ultra-personal device, such as a cell-phone. On the technical implementation, we plan to improve the tracking accuracy by employing the built-in acceleration sensors. In addition, we want to improve the detection range and angle by clustering several LEDs to act as a single LED to the wiimote's sensor. Furthermore, the loss of a LED (blinking, but switched-off during the capture) can be compensated by modulating the brightness of the LEDs instead of switching them off entirely.

References

[FKO03] T. Fuhrmann, M. Klein, M. Obendahl. The BlueWand as interface for ubiquitous and wearable computing environments. In Proceedings of the 5th European Personal Mobile communications Conference, pp. 91-95, 2003

[HBB07] O. Hilliges, D.Baur, A. Butz. Photohelix: Browsing, Sorting and Sharing Digital Photo Collections. In *Proceedings of the 2nd IEEE Tabletop Workshop*, Newport, RI, USA, 2007

[H03] K. Hinckley. Synchronous gestures for multiple users and computers. In *Proceedings of UIST 2003*, pp. 149–158, 2003

[KBP+00] H. Kato, M. Billinghurst, I. Poupyrev, K. Inamoto, K. Tachibana. Virtual Object Manipulation on a Table-Top AR Environment. In *Proceedings of the International Symposium on Augmented Reality*, pp. 111-119, Munich, Germany, 2000

[R97] J. Rekimoto. Pick-and-Drop: A Direct Manipulation Technique for Multiple Computer Environments. In *Proceedings of UIST'97*, pp. 31-39, 1997

[WS03] A. Wilson, S. Shafer. XWand: UI for intelligent spaces. In *Proceedings of CHI'03*, pp. 542-552, New York, NY, USA, 2003