TANGIBLE TOOLKITS

Integrating Application Development across Diverse Multi-User and Tangible Interaction Platforms

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Abstract. We are creating unified programming tools that allow developers to easily build applications for many different tangible platforms, and that can accommodate the continued evolution of the underlying sensing technologies. The Synlab API extends across several media table object-tracking platforms, RFID tagged object interactions, manipulable displays and multi-touch surfaces.

1. Introduction

While the digital realm enables a range of media content to be stored and manipulated, the promise of truly malleable digital information is limited by the means through which we can access the digital space. The interfaces that lie between our everyday physical environment and the digital world remain dominated by displays coupled with single-channel input devices (mice, keyboards). While these platforms are well suited for many desktop and mobile applications, it has been long acknowledged that they do not necessarily meet the needs of a multi-user application space in shared physical contexts such as living rooms, meeting rooms, classrooms and public spaces.

Over the past decade, researchers in areas such as tangible and ubiquitous computing have begun to address these needs by developing interaction techniques that can more seamlessly bridge the physical and digital worlds. Applications have been demonstrated across a range of domains, such as design and simulation, media content browsing, game play and learning. The technologies used to track people, objects and interactions in physical space range from computer vision, to infrared or ultrasonic sensing, radio frequency identification, and more.

In many cases however, the technologies used are not yet ready for prime time. Tangible application prototypes often demonstrate interaction methods that cannot be achieved using any single commercially available technical solution. As a result, they frequently use combinations of technologies or customized hardware setups, which in turn require custom communication and programming protocols. The complexity and cumbersome nature of the hardware setup makes application development for these novel platforms an arduous task that is mostly undertaken only as small-scale projects within user-interface research labs.

As the underlying technologies continue to change and develop, we can simultaneously mature the field of tangible interaction design by creating unified programming tools for developers. These tools could enable the creation of applications for many different kinds of tangible platforms while accommodating continued technological evolution.

2. Tangible Toolkit Research

The use of application programming interfaces (APIs) and toolkits is not new in software development, and enables programmers to rapidly create applications for computer interfaces that use traditional input/output devices. The concept has also been explored by some ubiquitous and tangible computing researchers. Many of these toolkits support low-level tangible interface design, allowing designers to assemble components such as sensors and actuators into hardware prototypes that can be interfaced to software applications using event-based communication. Notable examples include Crickets (Martin et al. 2000), Phidgets (Greenberg et al. 2001), iStuff (Ballagas et al. 2003), and the Calder Toolkit (Lee et al. 2004). A related area of toolkit research has focused on single-display groupware, such as multi-touch tables. Examples include DiamondSpin (Shen et al. 2004) and the SDGToolkit (Tse et al. 2004), which support touch or stylus-based user interactions rather than customized tangible objects.

In the Synaesthetic Media Lab at Georgia Tech, we are working mid-way between these approaches to develop an integrated application toolkit (the Synlab API) that allows developers to build applications for a range of tangible platforms and technologies. Our approach is similar to the Papier-Mâché toolkit (Klemmer 2003) which provides an event-based model for application development using RFID-tagged, barcoded, or computer vision identified objects. However we are extending our API to include a broader range of tangible platforms and technologies, such as acoustic-based object tracking media tables, tilting tabletops, spinning screens and more.

3. A Unified Toolkit for Tangible Platforms

The Synlab API is rooted in the creation of an API for the TViews media table, a multi-user display platform that supports interaction through the identification and real-time tracking of a virtually unlimited set of tagged objects. Early tangible tabletop applications were built using computer vision technology, and demonstrated the value of such platforms in design fields like urban planning and holography (Underkoffler et al. 1999). The computer vision setup was cumbersome and unreliable, requiring carefully calibrated cameras to be placed above or beneath a projection surface. The TViews system moved the sensing into the interaction surface using an electromagnetic tag-based approach, which eliminated some of the unreliability resulting from line-of-sight interference but still required an overhead projected display. The second generation of TViews uses an acoustic sensing method that works through a transparent surface, allowing a display screen to be embedded within the table (Mazalek 2005).

Figure 1. Role-playing and pente games running on different implementations of the TViews table which use electromagnetic sensing (left) and acoustic ranging (right) to locate the tangible objects on the display.

While each of these tabletop object tracking technologies is very different from a hardware perspective, they all provide the same basic functionality to application developers. For this reason, it is important to provide an API that hides the details of the underlying technology and allows developers to create end-user applications independent from the particularities of the technical solution used. The initial API for the TViews table provided a typical event-based system for application development. Tangible objects placed on the table trigger system events (e.g. object added, updated or removed) that are received by listening applications.

Since its initial creation as a media table programming toolkit, we have extended the Synlab API to include additional technologies and platforms, including RFID object tracking, multi-touch surfaces, and manipulable displays such as a tilting table and spinning screen. The latter two were constructed by PhD student Hyun Jean Lee, and allow users to interact with media content through physical actions exerted on the display surface, e.g.

tilting or spinning. The Synlab API can also be extended to support custom events for specific devices or platforms. For instance, the tangible objects on the acoustic-based media table support add-on input/output devices such as buttons and LEDs, which make use of custom input events (e.g. button press) and bi-directional messaging from applications (e.g. commands to turn on an LED). Figure 2 illustrates how applications interface with underlying tangible platforms via the Synlab API.

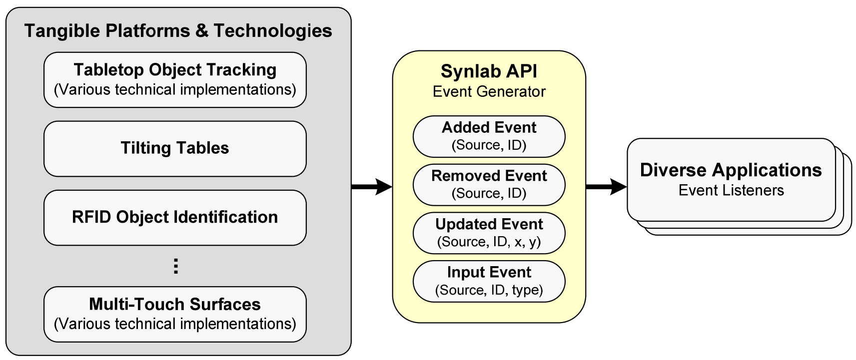

Figure 2. The event-based Sylab API supports application development across a diverse range of tangible platforms and technologies.

4. Application Examples

In parallel with the development of the Synlab API, we have also been creating media applications. Several examples are mentioned briefly here. Additional information can be found at: http://synlab.gatech.edu.

For tangible media tables, we have been exploring media content management applications, including geographic media browsing, photo sorting and digital storytelling. Many of these applications can also run on multi-touch surfaces without requiring changes to the application code. We are also developing tabletop board games and a multi-player role-playing game that makes use of custom tangible interaction objects, such as game characters, action tools and dice. For the tilting table, we are developing geographic map and biological data browsers. We are also exploring tracking of everyday user interactions with RFID-tagged objects for visualization and simulation of user activities in online social spaces.

In the future we plan to continue developing applications and extending the Synlab API to incorporate additional platforms and technologies.

References

Ballagas, R, Ringel, M, Stone, M and Brochers, J: 2003, iStuff: A Physical User Interface Toolkit for Ubiquitous Computing Environments, *Proceedings of CHI'03*, ACM Press.

Greenberg, S, Fitchett, C: 2001, Phidgets: Easy Development of Physical Interfaces through Physical Widgets, *Proceedings of UIST'01*, ACM Press.

Klemmer, SR: 2003, Papier-Mâché: Toolkit support for tangible interaction, *Proceedings of UIST'03*, ACM Press.

Lee, JC, Avrahami, D, Hudson, SE, Forlizzi, J, Dietz, P and Leigh, D: 2004, The Calder Toolkit: Wired and Wireless Components for Rapidly Prototyping Interactive Devices, *Proceedings of DIS'04*, ACM Press.

Martin, F, Mikhak, B and Silverman, B: 2000, MetaCricket: A designer's kit for making computational devices, *IBM Systems Journal*, 39(3-4).

Mazalek, A: 2005, *Media Tables: An extensible method for developing multi-user media interaction platforms for shared spaces*, Ph.D. Thesis, Massachusetts Institute of Technology.

Shen, C, Vernier, FD, Forlines, C and Ringel, M: 2004, DiamondSpin: An Extensible Toolkit for Around-the-Table Interaction, *Proceedings of CHI'04,* ACM Press.

Tse, E and Greenberg, S: 2004, Rapidly Prototyping Single Display Groupware through the SDGToolkit, *Proceedings of the Fifth Australasian User Interfaces Conference (AUIC2004)*, Australian Computer Society, Inc.

Underkoffler, J, Ullmer, B, Ishii, H: 1999, Emancipated Pixels: Real-World Graphics in the Luminous Room, *Proceedings of SIGGRAPH 1999,* ACM Press.