Actibles: Open Source Active Tangibles

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Abstract
Actibles are an open source hardware/software platform for creating active tangibles. Actibles contain a smartwatch core, which eases both hardware and software development, and enables application developers to leverage various web technologies. The smartwatch core is augmented by custom hardware that enables an expanded set of tangible interactions, including shaking, tilting, stacking and neighboring, as well as on-screen gestures and integrated LED feedback. Actibles can be used both independently or in conjunction with other devices, such as interactive tabletops. We describe the Actible's technical specifications and demonstrate several example applications.

Author Keywords
Active tangibles; tangible interaction; tabletop interaction; open source platform; smartwatch; LED feedback.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User interfaces – *input devices and strategies*, *interaction styles*, *prototyping*.

Introduction
Tangible, embedded and embodied interaction (TEI) is emerging as an important field within human-computer interaction research. TEI often enlists the use of physical

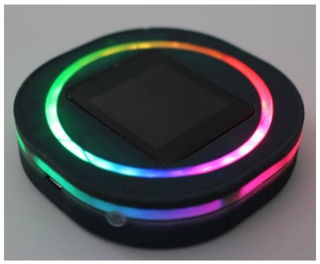

Figure 1: Actibles are a smartwatch-based active tangibles platform that incorporates additional sensors to detect stacking and neighboring, as well as LED feedback. The image shows an assembled Actible.

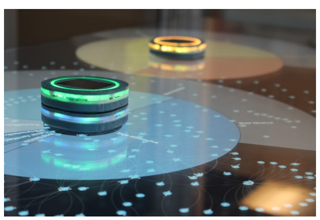

Figure 2: Three Actibles in the Sparse Tangibles application. The Two Actibles in the forefront are stacked to filter datasets on the tabletop surface.

objects, or "tangibles", to control and represent digital information [7]. Many TEI applications utilize passive (i.e. unpowered) tangibles. When augmented with a fiducial marker on their base, these tangibles can be tracked on interactive display surfaces (e.g., [2]). Today, there is an increased interest in active (i.e., powered) tangibles due to the increased number of interactive capabilities they can provide both independently and in combination with other interactive devices and surfaces.

Related Work

Building on existing work on active tokens [9] and active tangibles [1], we define active tangibles as physical input-feedback devices that can be used independently or in conjunction with other hardware or software to tangibly augment interaction with integrated displays, sensing, or actuation capabilities. Data querying and browsing (e.g., [1, 3, 8]), media content editing (e.g., [12]), and scientific discovery (e.g., [5]), are some of the tasks that have been explored using active tangibles.

While most applications that employ active tangibles have created custom built devices with interactive capabilities designed for specific application scenarios, there are also some examples of active tangibles that aim to serve as a general platform for diverse applications. The most notable example are the Siftables [4], which were later offered commercially as 'Sifteo Cubes'. Sifteo cubes were small cube-shaped units that included wireless communication, IrDA communication, a graphical display and sensing. They could detect a variety of interactions including shaking, neighboring, tilting, and tapping. However, Sifteo cubes did not offer support for multi-touch or stacking.

Interactions

Actibles (Fig. 1) are capable of five major types of interactions. These include tangible interactions, on-screen interactions, physical controls, tabletop interactions, and visual feedback. Developers can combine these interactions to yield new innovative interactions for specific applications.

Tangible Interactions

The following gestural interactions [10] with a single Actible are supported: tilting shaking and flipping. Additionally, gestural interactions with multiple Actibles include: bumping, neighboring and stacking.

On-Screen Interactions

Actibles incorporate a smartwatch display, and as a result, all common on-screen manipulations are offered to the end user. These on-screen interactions include double-tap, swipe and pinch/spread.

Physical Controls

Only one physical control is available on an Actible. This is a tactile button. Its main purpose is to switch power on or off, but it can also be used as a selector. This selector could be used in an application to confirm menu selection while scrolling via tilting or dialing.

Visual Feedback

Two types of visual feedback are offered on the Actible platform, namely a smartwatch display and an RGB LED array arranged in a ring. The smartwatch display may be used to view menus, messages or images, while the LED ring may be used to display colorful animations, dial feedback, or to affirm interaction detection.

Tabletop Interactions

By attaching fiducial markers to the bottom of the Actibles, they can be tracked on the surface of interactive displays such as ReacTIVision [2] or MultiTaction. All common tabletop interactions are supported on the surface such as moving, placing, removing and rotating, as well as all the Actible interactions described above.

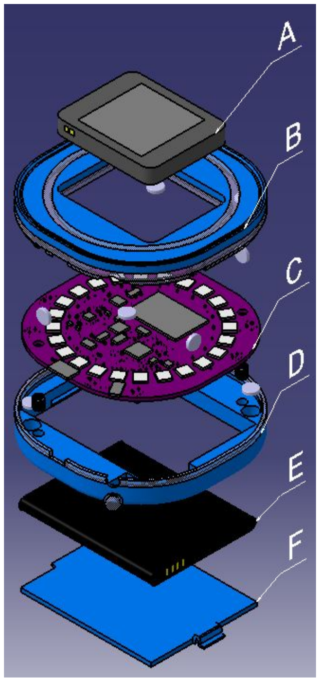

Figure 3: An exploded assembly view of the Actible showing: A) smartwatch, B) upper case, C) circuit board, D) lower case, E) smartphone battery, and F) battery cover.

Technical Implementation

The four main components that make up an Actible are the case, LG G smartwatch, circuit board, and battery (see Fig. 3). The case (Fig. 3, parts B, D and F) is designed to house the circuit board and battery. A battery access panel at the bottom of the Actible allows for quick battery removal (Fig. 3, part F). The inside walls of the case are designed with small inserts to house the magnets required for hall effect magnetic detection. This magnetic detection is what allows for stacking, bumping and neighboring.

A squircular shape was selected for the Actible's geometry. This design encourages intuitive neighboring, stacking and bumping alignment, while maintaining a circular geometry for dials and other circular or concentric applications.

In order for an Actible to function, basic software and firmware must be installed. The firmware is written in Arduino, however AVR support is inherent. Firmware is provided to interface the microcontroller with the power supervisory circuit in order to power on and shut down. Also, wifi module communication routines serve to establish wireless communication. Libraries are provided to enable developers to build applications based on the interactions described above.

Application Examples

Two existing projects, Active Pathways [6, 11] and Sparse Tangibles [1], were updated to use Actibles, demonstrating how previous active tangible implementations (in this case Sifteo cubes and custom tangibles, respectively) can be replaced with the Actibles platform. Tangible mtDNA is a new project that demonstrates the versatility of the Actibles.

Active Pathways

Active Pathways (Fig. 4) is a tangible tabletop biochemical modeling application. This application enables the construction and simulation of biochemical reaction networks using the Actibles both on and off the tabletop. A reaction network is constructed by "binding" the Actibles to components of the model (e.g., molecules, enzymes, reactions) and then touching them together to create connections between them. The tabletop interface allows the users to "fit" (i.e. match) of their model to selected experimental datasets by tweaking parameters such as reaction speeds and molecule concentrations with the Actibles.

Sparse Tangibles

Sparse Tangibles (Fig. 2) is a collaborative gene interaction network exploration application that employs Actibles for both on- and off-table interactions. Swipe and touch interactions on the Actibles are used to browse the BioGrid database and select genes/organisms. Actibles can also be associated with different filters (e.g., filter by number of connections), whose parameters are adjusted on the Actible display. A filter is then applied by stacking the given Actible on top of another Actible that is bound to a specific gene or organism. Placing gene/organism Actibles on the table displays the selected part of the network on the surface around them.

Tangible mtDNA

Tangible mtDNA (Fig. 5) allows users to gain insight into mitochondrial DNA sequencing mutation data for breast cancer patients using Actibles in combination with an interactive tabletop. Interactions such as shaking, stacking, and on-screen gestures with the Actibles both on- and off-table are used to query and visualize the dataset, which includes both DNA sequence/mutation data and clinicopathological features of patients. Users can also bind multiple Actibles to different queries within the dataset, and compare them by stacking the Actibles and placing them on the table. This results in a visualization that aligns the queries, so that users can, for example, compare mutations across genes based on different clinical features of patients.

Figure 4: Two Actibles in an off-table interaction in the Active Pathways application. Each Actible is bound to a molecule and touching them together creates a reaction between the two molecules.

Figure 5: An Actible being used on table to view DNA sequence mutation data in the mtDNA application

Conclusion

We presented Actibles, an open-source platform that enables researchers and developers to better explore the use of active tangibles in their applications. We described the interactions and technical implementation of the platform, and demonstrated its use in three application scenarios. Future work will involve hardware improvements, including the exploration of newer smartwatch models as well as open source/open hardware single board solutions.

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REFERENCES

[1] Arif, A. S., Manshaei, R., Delong, S., East, B., Kyan, M., and Mazalek, A. Sparse tangibles: Collaborative exploration of gene networks using active tangibles and interactive tabletops. In *Proc. TEI '16*, ACM (2016), 287–295.

[2] Kaltenbrunner, M., and Bencina, R. reactivision: a computer-vision framework for table-based tangible interaction. In *Proc. TEI '07*, ACM (2007), 69–74.

[3] Klum, S., Isenberg, P., Langner, R., Fekete, J.-D., and Dachselt, R. Stackables: Combining tangibles for faceted browsing. In *Proc. AVI '12*, ACM (2012), 241–248.

[4] Merrill, D., Kalanithi, J., and Maes, P. Siftables: Towards sensor network user interfaces. In *Proc. TEI '07*, ACM (2007), 75–78.

[5] Okerlund, J., Segreto, E., Grote, C., Westendorf, L., Scholze, A., Littrell, R., and Shaer, O. Synflo: A tangible museum exhibit for exploring bio-design. In *Proc. TEI '16*, ACM (2016), 141–149.

[6] Shaer, O., Mazalek, A., Okerlund, J., Grote, C., and Ullmer, B. Tangible interaction with large data sets using active tokens. In *CHI '15 Workshop, Exploring the Challenges of Making Data Physical* (2015).

[7] Ullmer, B., and Ishii, H. Emerging frameworks for tangible user interfaces. *IBM Syst. J. 39*, 3-4 (July 2000), 915–931.

[8] Ullmer, B., Ishii, H., and Jacob, R. J. Tangible query interfaces: Physically constrained tokens for manipulating database queries. In *Proc. INTERACT*, vol. 3 (2003), 279–286.

[9] Ullmer, B., Ishii, H., and Jacob, R. J. K. Token+constraint systems for tangible interaction with digital information. *ACM Trans. Comput.-Hum. Interact. 12*, 1 (Mar. 2005), 81–118.

[10] Valdes, C., Eastman, D., Grote, C., Thatte, S., Shaer, O., Mazalek, A., Ullmer, B., and Konkel, M. K. Exploring the design space of gestural interaction with active tokens through user-defined gestures. In *Proc. CHI '14*, ACM (2014), 4107–4116.

[11] Wu, A., Yim, J.-B., Caspary, E., Mazalek, A., Chandrasekharan, S., and Nersessian, N. J. Kinesthetic pathways: A tabletop visualization to support discovery in systems biology. In *Proc. C&C '11*, ACM (2011), 21–30.

[12] Zigelbaum, J., Horn, M. S., Shaer, O., and Jacob, R. J. K. The tangible video editor: Collaborative video editing with active tokens. In *Proc. TEI '07*, ACM (2007), 43–46.