Motion-Based Interaction for Handheld Devices

Sung-Jung Cho
SAIT (Samsung Research)
P.O. Box 111, Suwon, Korea
sung-jung.cho@samsung.com

Wonchul Bang
SAIT (Samsung Research)
P.O. Box 111, Suwon, Korea
wc.bang@samsung.com

Changkyu Choi
SAIT (Samsung Research)
P.O. Box 111, Suwon, Korea
changkyu_choi@samsung.com

Yeun-Bae Kim
SAIT (Samsung Research)
P.O. Box 111, Suwon, Korea
kimbae@samsung.com

Eunseok Choi
SAIT (Samsung Research)
P.O. Box 111, Suwon, Korea
eunseok.choi@samsung.com

CHI 2007, April 28–May 3, 2007, San Jose, California, USA.
ACM 978-1-59593-642-4/07/0004.

Abstract
Exertion interface in mobile devices means that users interact with devices by physical movements. We review a motion-based interaction in mobile devices as its example. Users do not use buttons or mice but move their hands for controlling them. For portability of devices, self-contained sensors such as accelerometers and gyroscopes are required. We summarize categories of motion-based interactions. Then, we present gesture-understanding remote controllers and cell phones. Their applications include gesture-dialing in the air, TV control by gestures, playing musical instruments, simulating physical activities and browsing photos by tilting. Users comment that it is quite interesting even though it may not be as efficient as buttons.

Keywords
Motion-understanding cell phones, tilting, shaking, gesture recognition, accelerometer, gyroscopes

ACM Classification Keywords
H.5.2 User Interfaces: Input devices and strategies

Introduction
As mobile devices have embedded more computing power and sensors, the needs for natural and intuitive interaction become larger. In mobile contexts, keypads and mice may not be affordable because of the lack of users' visual attention and the physical size limitation

A motion-based interaction denotes an interaction method which utilizes hand movement for controlling devices. It has following advantages as an exertion and natural interfaces. First, it is natural for simulating physical activities in the real world like playing drums, shaking objects and playing sports games. Keypads can be also used for giving the same input even more accurately, but are not as much fun and interesting as the motion-based one. Second, it is an 'eye-free' interface. Therefore, it is especially useful for activities related with audio feedback like changing music tracks by gestures without looking at the screen. It may be also helpful to the blind. Finally, it enables innovative physical layout design of devices because it requires at most one activation button. Therefore, devices can be more portable and have more screen space.

The interaction requires self-embedded sensors in mobile environment usage. Hand motion can be also detected by external sensors such as IR or ultrasonic wave sensor-receiver pairs, or touch-sensitive surface tablets. Even though they have small position errors along time, they can not be used outside the controlled environment. On the other hand, the self-embedded one uses inertial sensors or image sensors for tracking hand trajectories. It has somewhat large position errors along time. However, it can be used in any place without external sensor installation. Therefore, we employed it with robust signal processing algorithms.

Motion-understanding devices [1][2]

To apply motion-based interaction, we designed two hand-held devices: an one-button remote controller and a gesture phone (Fig. 1). The cell phone has battery, memory, processor and ADC for digitizing sensor values. It has only tri-axis accelerometer sensor because of PCB size limitation. The remote controller has additionally gyroscopes and IR transmitter for TV. Both have one gesture activation button for inputting motion.

Fig. 1 Motion-understanding devices

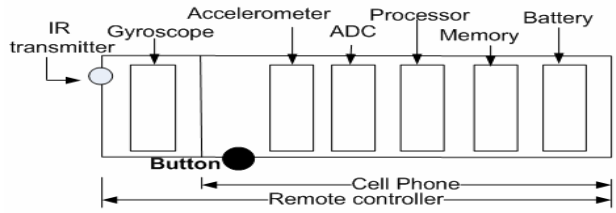

Fig. 2 HW components of motion-understanding devices

Motion-based Interaction and applications

Users interact with mobile devices by three kinds of motions: tilting, shaking and drawing gestures as shown in Fig. 3. In tilting, when users tilt the device without other movement, the tilt angle is calculated by comparing gravity components in three axes. In shaking, the time and strength of users' shaking activities are detected by analyzing the size of signal variations in a time interval. In drawing gestures, the patterns of trajectories in 3-D space are matched by gesture models with pattern recognition algorithms.

Some applications of motion-based interactions are shown in Fig. 4. In Fig. 4 (a), the direction of tilting angle is used for scrolling photos. A dynamics model is applied for making photos converged to the center of screen naturally for enhancing the controllability of photo browsing task. A quantitative and qualitative study showed that users can control devices more accurately with buttons [3]. However, they prefer the tilting because it is more interesting.

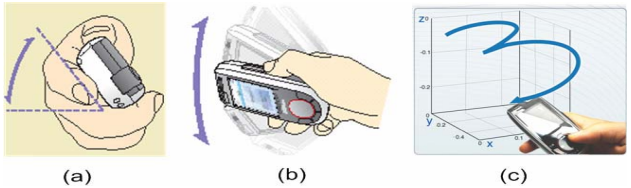

Fig. 3 Categories of motion-based interaction

In Fig. 4 (b), the time and direction of shaking activities make dices move realistically. By relating the shaking activities and physical dynamics of dice, the simulation becomes more realistic. We also made an application called 'beat box' and 'orgol' which synthesize musical instrument sounds and play music notes by relating the shaking time and the playing time of music notes [4]. By providing sound feedback like sound of rolling dices, the sensation of reality becomes further increased. Nintendo WII game devices have also employed the shaking-based interaction for sports games like boxing, playing tennis and throwing cows in enhancing reality.

In Fig. 4 (c), the patterns of users' movement are used for inputting symbols and controlling devices. Users make speed-dialing by drawing numbers in the air. Also, they change song tracks by drawing gestures. In case of the remote controller, they change channels and volumes by drawing numbers or gestures. Gesture shapes are collected from users and used for training gesture models. Then the input is matched to the gesture models for searching the most similar one.

Fig. 4 Applications of motion-based interaction

Summary

Motion-based interaction utilizes hand movement for controlling devices by tilting, shaking and drawing shapes. It is natural and interesting for simulating physical activities and providing eye-free interaction. Our future research aims at enhancing reality by coupling it with multi-modal input and output, and studying the feasibility of gestures for controlling devices and their benefits to users.

References

[1] W.C. Bang, et. al, "SCH-S310: Gesture Understanding Cell phone," *7th Mobile HCI*, 2005

[2] S.-J. Cho, et. al, "MagicWand: A hand-drawn gesture input device in 3-D space with inertial sensors," 9th *IWFHR*, Tokyo, 2004

[3] S.-J. Cho et. al, "Dynamics of Tilt-based Browsing on Mobile Devices," *CHI Extended Abstract*, 2007

[4] E.-S. Choi, et. al, "Beatbox Music Phone: Gesture Interactive Cell phone using Tri-axis Accelerometer," *IEEE ICIT*, 2005