Ubitile: A Finger-Worn I/O Device for Tabletop Vibrotactile Pattern Authoring

Khanh-Duy Le
t2i Interaction Laboratory
Chalmers University of Technology
khanhd@chalmers.se

Kening Zhu
School of Creative Media
City University of Hong Kong
Hong Kong
keninzhu@cityu.edu.hk

Tomasz Kosinski
Morten Fjeld
t2i Interaction Laboratory
Chalmers University of Technology
kosinski@chalmers.se
fjeld@chalmers.se

Maryam Azh
Shengdong Zhao
NUS-HCI Lab
National University of Singapore
zhaosd@comp.nus.edu.sg
maryam@nus.edu.sg

NordiCHI '16, October 23-27, 2016, Gothenburg, Sweden
ACM 978-1-4503-4763-1/16/10.
http://dx.doi.org/10.1145/2971485.2996721

Abstract
While most mobile platforms offer *motion sensing* as input for creating tactile feedback, it is still hard to design such feedback patterns while the screen becomes larger, e.g. tabletop surfaces. This demonstration presents Ubitile, a finger-worn concept offering both motion sensing and vibration feedback for authoring of vibrotactile feedback on tabletops. We suggest the mid-air motion input space made accessible using Ubitile outperforms current GUI-based visual input techniques for designing tactile feedback. Additionally Ubitile offers a hands-free input space for the tactile output. Ubitile integrates both input and output spaces within a single wearable interface, jointly affording spatial authoring/editing and active tactile feedback on- and above- tabletops.

Author Keywords
Vibrotactile pattern authoring; ring-like device; surface computing.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Multi-touch surfaces have become common in both private and public settings, with multimodal visual, audio and tactile interactions, attracting more and more research interest. While it is common to provide tactile output in mobile devices through their inbuilt vibrators, it is more challenging to generate such output with larger touch surfaces.

Most previous research has focused on recreating this tactile feedback on interactive surfaces [1][2][3][4][5] There has been much less research into novel authoring methods for tabletop vibration patterns, with the GUI-based authoring techniques [6][7][8][9][10] most often being used in different touch-surface platforms. We believe the unique form factor of a tabletop can benefit from a different authoring method tailored for vibrotactile feedback on an interactive surface. This demonstration presents Ubitile, a finger-worn ring-type device that jointly affords spatial finger movement recognition and active vibration feedback on- and above- tabletops, supporting the creation of vibrotactile patterns through finger motions with real-time tactile feedback.

Related Works

In this section, we discuss the two areas addressed by this demonstration, finger-worn devices for tabletop tactile feedback and input techniques for authoring of tactical feedback on the interactive surface.

Finger-worn Tactile Interfaces for Tabletop Interaction

Wusheng et al. [4] combined data gloves and robotics to offer haptic feedback. Rekimoto [2] presented a haptic interaction system with a mobile or finger-mounted module consisting of a photo-detector with a tactile actuator. Weiss et al. [3] developed FingerFlux, providing simulated haptic feedback to the fingertip when operating above an interactive tabletop.

Input Techniques for Authoring tactile feedback

Traditionally, tactile and other haptic interfaces were manipulated at hardware level, or using a graphical interface. Choi et al. developed a series of GUI-based vibrotactile-authoring software [7][9][10], supporting the creation of vibration patterns through sketching and demonstration. On the other hand, non-visual gesture-based interaction as a less explored area, suggests an alternative approach for tactile pattern customization. Operating with gesture-based techniques on a wearable device removes the extra visual layer and offers a real-time interaction during the tactile customization process. Rantala et al. [11] proposed a hand-held device that integrates touch and motion sensing for designing spatial tactile feedback.

Our contribution distinguishes itself by:

1. Investigating finger-motion-based authoring techniques for vibrotactile patterns.
2. Mapping the finger motion to the vibrotactile output space.
3. Identifying the application domains for this technique

System Design

Vibration pattern properties

In this demonstration, each digital object on the tabletop surface can be associated with a vibration pattern, and a vibration pattern is composed of one or more vibration units. Each vibration unit contains two properties: intensity and duration. The intensity

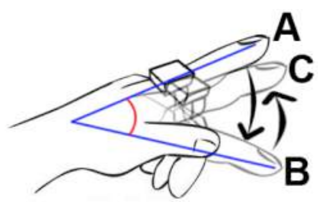

Figure 1: Finger waving for vibrotactile authoring.

Figure 2: Holding on the object to toggle the "REC" button.

Figure 3: Waving the finger to author the vibrotactile pattern.

determines the strength of the vibration unit and the duration is how long it lasts. Between two consecutive vibration units in a pattern, there is a gap where the vibration intensity is zero to help distinguish the two vibration units. In this demonstration, users will adjust these three properties (vibration unit intensity, vibration unit duration and between-units gap) to author a vibration pattern. Our system was designed to allow users to intuitively author a vibration pattern by waving a finger. Details regarding the system's setup as well as our proposed authoring technique will be described in the following sections.

Mapping finger movements to vibration pattern

We use the pitch rotational angle acquired by the gyroscope to capture the user's finger movement. When the user waves his/her finger downwards from A to B and then upwards from B to C (which is not necessarily different from A as in Figure 1), three aforementioned properties of a vibration pattern will be mapped from different features of the finger movement as follows:

Vibration unit intensity: the pitch difference between positions B and A is mapped to the intensity of the corresponding vibration unit.

Vibration unit duration: the time the finger travels from A to B is mapped to the duration of the corresponding vibration unit.

Between-unit gap: the time the finger travels from B to C is mapped to the corresponding between-units gap.

The number of vibration units in the pattern is the number of times the user waves his/her finger down, and the number of gaps between two consecutive units are the times the user waves the finger up.

System setup and interaction technique

The system consists of two main components: a tabletop and a ring (Figure 2 & Figure 3). The tabletop is a Samsung SUR40 which uses PixelSense technology allowing multi-touch interaction. It displays the media objects which users can choose to author their associated vibration pattern. The ring is equipped with various sensors (accelerometer, gyroscope, magnetometer) and a vibrator. The sensors record movements of the user's finger wearing the ring and the vibrator allows the user to render the created vibration pattern.

To author a vibration pattern associated with a digital object, a user needs to perform the following steps:

Step 1: Select the target object on the tabletop by touching on it with two fingers. A context menu will show up with a recording button (Figure 2).

Step 2: Keep pressing the recording button and author the associated vibration pattern by waving the finger wearing the ring (Figure 3).

Step 3: Release the recording button to stop recording the finger's movement.

Step 4: Choose to save or discard the recorded movement by pressing the corresponding buttons.

After saving the created pattern, whenever a user touches the media object, he/she can feel the vibration pattern rendered by the ring.

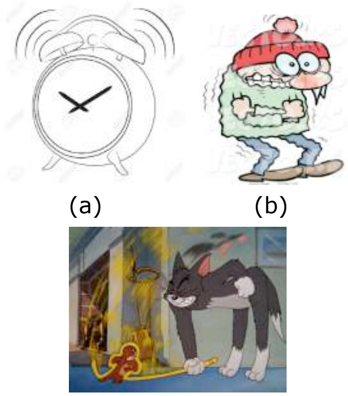
(a) (b) (c)

Figure 4: Examples of static images for vibrotactile authoring.

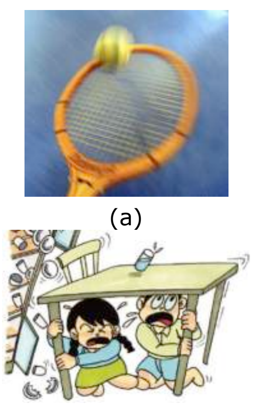
(a) (b)

Figure 5: Examples of video/animation for vibrotactile authoring.

Application/Demonstration Scenario

Authoring Vibrotactile Patterns for Static Images (Comics)

Motion lines are commonly used to indicate the properties of movements, such as speed, trajectory, vibration, etc., of characters in static comics. We demonstrate authoring with three static comic images (Figure 4), supposedly corresponding to three different vibrotactile feelings.

Authoring Vibrotactile Patterns for Animation/Video

Animated images can also illustrate vibrotactile feedback. In this demonstration, users can choose to author vibration patterns for three types of animations which are supposed to correspond to different vibrotactile feedback levels. Those animations (Figure 5) include the vibrating strings of a tennis racquet and an earthquake.

Future Work

In the future, user studies will be needed to evaluate our proposed method of mapping finger movements to vibration patterns. First, we will evaluate whether vibration patterns generated by finger movements are intuitive to users and similar to their expectation or not. Second, we will conduct studies to find out which finger movement features are best to represent the properties of a vibration pattern.

References

[1] Bau, O., Poupyrev, I., Israr, A., and Harrison, C. Teslatouch: electrovibration for touch surfaces. In Proc. UIST 2010, ACM Press (2010), 283–292.

[2] Rekimoto, J. Senseablerays: opto-haptic substitution for touch-enhanced interactive spaces. In Ext. Absstracts CHI 2009, ACM Press (2009), 2519–2528.

[3] Weiss, M., Wacharamanotham, C., Voelker, S., and Borchers, J. Fingerflux: near-surface haptic feedback on tabletops. In Proc. UIST 2011, ACM Press (2011), 615–620.

[4] Wusheng, C., Tianmiao, W., and Lei, H. Design of data glove and arm type haptic interface. In Proc. HAPTICS 2003 (2003), 422 – 427.

[5] Jansen, Y., Karrer, T., and Borchers, J. Mudpad: localized tactile feedback on touch surfaces. In Adj. Proc. UIST 2010, ACM Press (2010), 385–386.

[6] Nam, S., & Fels, D. Design and Evaluation of an Authoring Tool and Notation System for Vibrotactile Composition. In Proc. UAHCI 2016, 43-53. Springer International Publishing.

[7] Ryu, J., & Choi, S. posVibEditor: Graphical authoring tool of vibrotactile patterns. In Haptic Audio visual Environments and Games, 2008. HAVE 2008, 120-125. IEEE.

[8] Park, T., Hwang, J., & Hwang, W. Facilitating the design of vibration for handheld devices. In Proc. HCI International 2009, 496-502. Springer Berlin Heidelberg.

[9] Hong, K., Lee, J., & Choi, S. Demonstration-based vibrotactile pattern authoring. In Proc. TEI 2013, 219-222. ACM.

[10] Lee, J., Ryu, J., & Choi, S. Graphical authoring tools for vibrotactile patterns. In EuroHaptics 2009, 388-389. IEEE.

[11] Rantala, J., Raisamo, R., Lylykangas, J., Ahmaniemi, T., Raisamo, J., Rantala, J., Mäkelä, K., Salminen, K., and Surakka, V. The Role of Gesture Types and Spatial Feedback in Haptic Communication. IEEE Transactions on Haptics, 4(4), 2011.