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

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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 tactile feedback on the interactive surface.

Finger-worn Tactile Interfaces for Tabletop Interaction

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
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.
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