An Authoring Tool for Vibrotactile Images

Da-Hye Kim, Won-Hyung Park, In-Ho Yun, Jeong Cheol Kim and Sang-Youn Kim

Abstract**—**This paper presents an authoring tool which makes a user easily and intuitively design vibrotactile sensation. A mobile hardware platform powered by ANDROID, a multi-purpose haptic driver and a linear resonance actuator are used to implement the system of the presented authoring tool. The tool allows users to easily and simply create a vibrotactile sensation by drawing vibrotactile images and to feel the sensation by rubbing drawn images on the touch screen of a mobile device. The tool supports a graphical interface for designing, editing and playing vibrotactile images as well as a pre-defined file format for save and open.

Keywords**—** authoring tool, mobile device, vibrotactile pattern, vibrotactile sensation

I. INTRODUCTION

VARIOUS types of mobile devices based on a touch screen panel(a TSP), for instance a smart phone, a PDA, a tablet PC, and etc., have been spread out widely. As physical buttons on mobile devices have been replaced with virtual buttons on a touch screen panel in order to maximize the visual display unit, users can hardly feel the sense of manipulation. Therefore, the touch information can be one of the important factors in mobile devices for increasing operation feeling as a user presses a real button.

Haptics refers the technology to generate touch sensation and convey it to a user via a haptic interface. Haptic sensation is mainly classified in two categories: kinesthetic sensation and tactile sensation. Kinesthetic sensation, which is sensed through muscle, enables a person to figure out an object's shape and hardness. Tactile sensation, which is sensed through human skin, makes a person perceive an object's roughness and temperature.

In order to convey haptic sensation, a lot of haptic interface have been developed. The most famous haptic interface for kinesthetic sensation is PHANToM^{TM} developed by SensAble technologies [1]. Virtuose suggested by Haption is also widely used [2]. Novint presented a 3 DOF haptic interface at a low price [3]. EPFL and Force Dimension developed Omega/Delta device which can compensate the effect of gravity using a parallel structure [4, 5]. Even though these interfaces are suitable for conveying kinesthetic sensation, it is not easy to apply these interfaces to small devices. The reason is that kinesthetic interfaces are too bulky to be directly embedded into mobile devices. In order to provide haptic sensation to mobile users, researchers have focused on vibrotactile actuators. T. Ahmaniemi *et al.* have researched on generating twelve different virtual textures using a vibration motor [6]. E. Hoggan *et al.* suggested the way to deliver massages with rhythmical vibrotactile sensations called tacton [7]. T. Pakkanen *et al.* found the optimal sensation when a user's figure tip went into and got out of several virtual buttons [8]. S.Y. Kim *et al.* proposed a vibrotactile rendering for conveying the information of virtual environment [9]. S.Y. Kim *et al.* conveyed the sensation of an object's movement using traveling vibrotactile wave [10]. These research works are meaningful to improving the sense of manipulation by providing various vibrotactile sensations compared to the previous simple vibration.

Although the research works on vibrotactile rendering have been actively progressed, the works on an authoring tool for easy generation of haptic feedback have been started recently. M. J. Enriquez *et al.* presented a graphical interface named "Hapticon Editor" to create and edit kinesthetic feedback [11]. Immersion corp. developed a GUI interface, called VibeTonz system that enables users to create vibrotactile patterns using pre-defined blocks on a mobile device [12]. J. Ryu *et al.* proposed a graphical interface called "posVibEditor" to design vibrotactile waveforms by editing control points [13]. J. Lee *et al.* presented a vibrotactile authoring tool which provides a musical score interface to design vibrotactile sensation [14].

Although these systems become practical interfaces for designing haptic feedback, it is not easy for users having no prior knowledge to edit voltage-time graphs or compose scores. Therefore, we present an authoring tool that becomes an easy, intuitive and user-friendly interface and makes users create vibrotactile sensation without any prior knowledge. Using the proposed authoring tool, users can be conveyed their own vibrotactile sensation by simply drawing vibrotactile images and rubbing the drawn images.

The proposed authoring tool supports:

- Easy, funny and user friendly designing process,
- A drawing method for creating vibrotactile images,
- A graphical interface for designing, editing and playing vibrotactile images,
- An image-based playing paradigm not time-based
- A pre-defined data file format for save and open,
- Targeting a Linear Resonance Actuator(LRA), and

This work has been supported by the S/W Computing R&D program of MKE/KEIT(10035360-2010-01,TAXEL: Visio-haptic Display and Rendering Engine). This work has been also supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology(grant number : 20100012455)

First author : D. H. Kim, is with Korea University of Technology and Education (e-mail: morbid@naver.com).

Corresponding author : S. Y. Kim is with the Korea University of Technology and Education (corresponding author to provide e-mail: sykim@kut.ac.kr).

- Quick playback function after designing.

II. System Overview

In this paper, we propose a vibrotactile authoring tool on a mobile platform with a touch screen panel for straightforwardly creating, editing and playing a vibrotactile sensation. For easily designing vibrotactile sensation, we defined a "vibrotactile image" as the representation of vibrotactile sensation. Using the proposed tool, users can design a vibrotactile sensation by drawing a vibrotactile image and play the vibrotactile sensation by rubbing the drawn image.

Fig. 1 shows the system architecture of the proposed vibrotactile authoring tool. The tool consists of three major components: a vibrotactile image editor, a vibrotactile image player and a data manager. Functions provided by these components are accessible by menus shown in Fig. 2. In order to maximize a drawing area (Fig. 2-a)), we use a drawer menu form or a pop-up menu form in implementing the authoring tool's menus.

Using the vibrotactile image editor, users can draw a vibrotactile image by selecting a figure from the draw menu shown in Fig. 2-b) and dragging on the screen. The interface for editing a drawn image is also provided as shown in Fig. 2-c). The vibrotactile image player extracts haptic information from the drawn vibrotactile image and computes the operating voltage input for a target actuator to haptically play the vibrotactile image. The data manager provides an interface to save and to load the information of the vibrotactile image. The functions given by the vibrotactile image player and the data manager are available from the main menu of the tool as shown in Fig. 2-d).

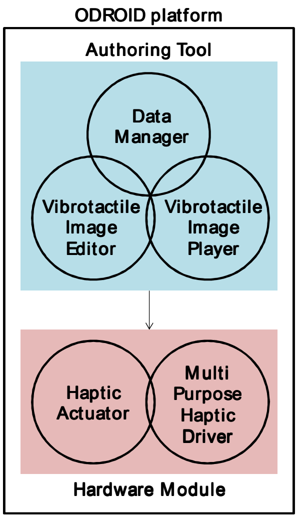

Fig. 1 System architecture

As implied above, the user interface of the proposed authoring tool supports user-friendly interaction which enable user to easily create vibrotactile sensation and intuitively play it. For example, a user can make vibrotactile sensation by drawing an image and play vibrotactile sensation by rubbing the drawn image. Several examples of the vibrotactile images are shown in Fig. 3. As shown in Fig. 3, various images can be drawn using the proposed authoring tool. These drawn images can be played by rubbing the touch screen.

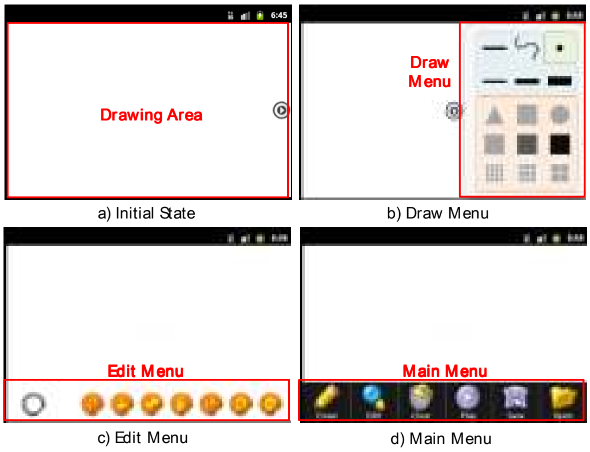

Fig. 2 Menus provided by the proposed authoring tool

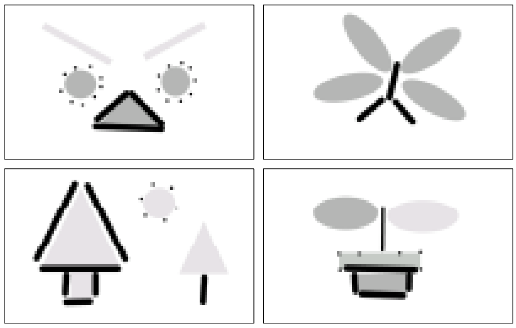

Fig. 3 several examples of vibrotactile images

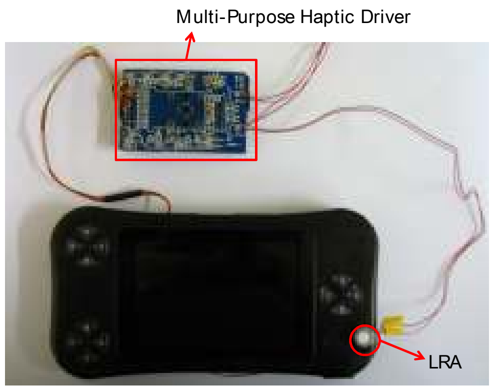

Fig. 4 The implemented system for the authoring tool

The vibrotactile authoring tool was constructed on the ODROID [15], which is a mobile hardware platform powered by ANDROID. In order to drive a haptic actuator directly from the tool, we employed a multi-purpose haptic driver, which supports an I^2C or SPI interface [16]. In this study, we used a single linear resonant actuator (an LRA), which is attached to right-bottom area of ODROID as shown in Fig 4, to generate vibrotactile sensation.

III. Vibrotactile Image Editing and Playing

The proposed authoring tool has two modes: a drawing mode and a playing mode. Fig. 5 shows the signal flow of the proposed authoring tool. In Fig. 5, orange colored boxes show the signal flow in playing mode, a blue colored box shows the signal flow in the drawing mode and a black colored box is activated in both modes. In the drawing mode, vibrotactile images are drawn or edited by user's touch on a screen and the result is presented on the visual display. For editing vibrotactile images, a user can not only zoom in/out, translate, and rotate target images but also copy, delete, and group images.

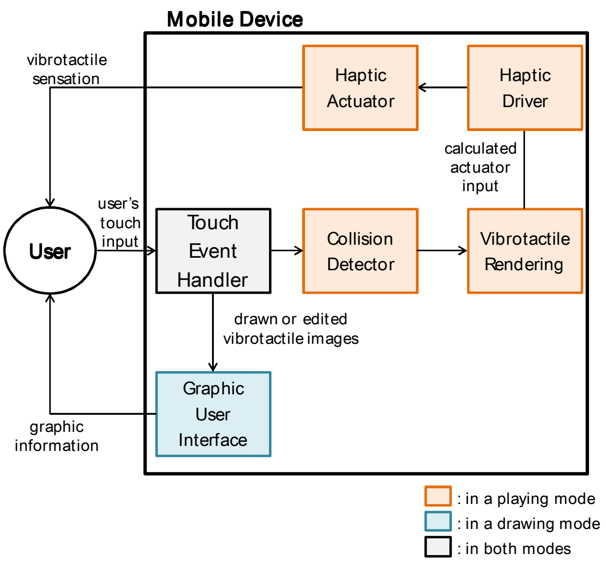

Fig. 5 Signal flow of the proposed authoring tool

In the playing mode, a collision detector checks to collide between the drawn image and the position (p_t) where a user touches on the visual display unit. If there is a collision between the drawn image and p_t, vibrotactile rendering module produces a control input and conveys it to haptic driver through I^2C interface. The haptic driver then controls the haptic actuator as the received control input to create vibrotactile sensation. Finally, the created vibrotactile sensation is delivered to users.

IV. Data Management

For convenience, the proposed authoring tool supports a save/load functions. Vibrotactile images drawn by users can be saved as both a pre-defined file format and portable network graphics file format (a .png file format). Fig. 6 shows the internal structure of the pre-defined file format. All elements corresponding to a drawn vibrotactile image on a screen are saved in the order of being drawn. Elements' position and properties information is saved. We used XML structure to implement save/load functions and furthermore, we saved the image data on a secure digital card (an SD card) for portability and compatibility.

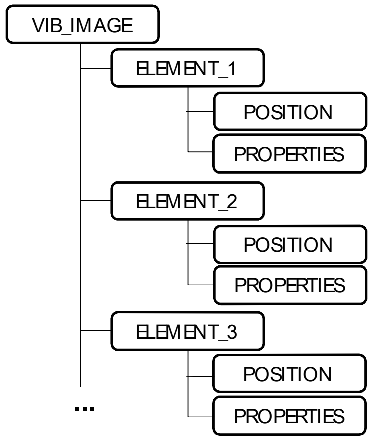

Fig. 6 Internal structure of vibrotactile image's file format

V. Conclusion

In this paper, we developed a vibrotactile authoring tool which makes it possible for users to easily create/edit/play vibrotactile sensation on a touch screen based on a mobile device. For easily designing vibrotactile sensation, we defined a "vibrotactile image" as a representation of a vibrotactile sensation. The proposed tool allows users to create a vibrotactile sense by drawing a vibrotactile image and play the sensation by rubbing the drawn image. The user interface, like drawing/rubbing images, supports intuitive interaction between the tool and users. Moreover, we introduced a pre-defined file extension to save/load vibrotactile images. It is expected that user experience in the mobile environment can be enhanced through the proposed vibrotactile authoring tool.

Acknowledgment

The authors wish to thank Sung-Uk Park for having made useful suggestion.

References

[1] http://www.sensable.com
[2] http://www.haption.com
[3] http://home.novint.com
[4] http://www.epfl.ch
[5] http://www.forcedimension.com
[6] T. Ahmaniemi, J. Marila and V. Lantz, "Design of Dynamic Vibrotactile Textures," IEEE Transactions on Haptics, Vol. 3, No. 4, October-December 2010
[7] E. Hoggan and S. Brewster, "New Parameters for Tacton Design," CHI 2006
[8] T. Pakkanen, R. Raisamo, J. Raisamo, K. Salminen and V. Surakka, "Comparison of three designs for haptic button edges on touchscreens, " 2010 IEEE Haptics Symposium
[9] S.Y. Kim, K.Y. Kim, B.S. Soh, G. Yang, and S.R. Kim, "Vibrotactile Rendering for Simulating Virtual Environment in a Mobile Game," IEEE Transactions on Consumer Electronics, Vol. 52, No. 4, November 2006, pp. 1340-1347
[10] S.Y. Kim, J.O. Kim, K. Y. Kim, "Traveling Vibrotactile Wave - A New Vibrotactile Rendering Method for Mobile Device," IEEE Transactions on Consumer Electronics, Vol. 55, No. 3, August 2009
[11] M. J. Enriquez and K. E. MacLean, "The hapticon editor: A tool in support of haptic communication research," in Proceedings of the 11th

Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, 2003, pp. 356–362.
[12] Immersion Corp., "Mobility overview," Immersion Corp., 2007, http://www.immersion.com/mobility.
[13] J. Ryu and S. Choi, "posVibEditor: Graphical Authoring Tool of Vibrotactile Patterns," HAVE 2008
[14] J. Lee, J. Ryu and S. Choi, "Vibrotactile Score: A Score Metaphor for Designing Vibrotactile Patterns," Third Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, 2009
[15] http://www.hardkernel.com/products.php
[16] S.Y. Kim and J. C. Kim, "Traveling Vibrotactile Wave Based on a Haptic Processor," 2011 IEEE International Conference on Consumer Electronics