Multi-touch Surface Table with Multi-point Tactile Feedback

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Abstract. Currently, most of multi-touch surface tables do not provide any tactile feedback to the users. In this paper, a multi-touch surface table with tactile feedback is proposed. The proposed surface table provides the users with the ability of multi-point tactile feedback with variant patterns and levels of vibrations. A webcam is used to capture all finger-touch images as system inputs using computer vision. Interactive computer graphics is generated and projected on the surface table. In addition, the multi-point tactile feedback is produced by multiple motors attached below the display surface. Hence, the user will receive tactile feedback synchronized with multi-point interactive computer graphics.

Keywords: Surface-based Display/ Multi-touch Display/ Tactile Feedback.

1 Introduction

Multi-touch technology becomes more popular in daily life. It is integrated with several electronic devices such as mobile phones with touch screens, touch screen monitors, and etc. One of the advanced multi-touch products is a multi-touch surface table. It allows the user to directly interact with a system using finger touch on the screen display. Furthermore, it is able to support multiple users to work together on the same multi-touch display table. Earlier research works in the field of multi-touch surface have introduced various methods for touch detection. Jeff Han proposed the frustrated total internal reflection (FTIR) [1] technique that is based on the light totally reflected phenomenon. He implemented infrared lights inundating inside a piece of clear acrylic screen. When the user touches a surface, the infrared lights will leave the acrylic screen to the touching points captured by a camera behind the acrylic screen. Katz, I., Gabayan, K., and Aghajan, H. proposed a multi-touch surface using multiple cameras technique for determining the fingertip's positions [2]. The capacitive coupled technique for detecting finger touches on the tabletop front-projected display in DiamondTouch [3]. There are also touch screens with tactile feedback for small handheld devices developed by Ivan, P., Jun, R., and Shigeaki, M. [4, 5].

However, most of multi-touch surface table does not provide tactile feedback. Hence, this paper proposes a multi-touch surface table with multi-point tactile feedback that can provide haptic senses during the user interacts with a system.

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2 System Overview

Figure 1 shows the configuration of the proposed system. Hardware components of this system are a multi-touch display table and a tactile feedback system. This human-computer interface provides the user with tactile feedback and 2D computer graphics on the display surface. A webcam attached in the multi-touch display table is applied for detecting finger touch image. Array of small motors, which are attached below the display surface, are used to generate multi-point tactile feedback synchronized with graphics.

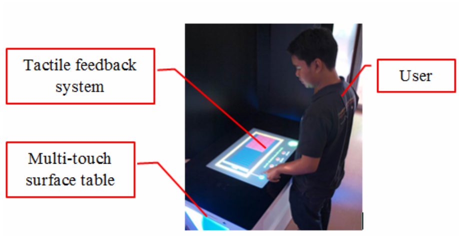


Fig. 1. System Overview

2.1 System Components

The dimension of the proposed multi-touch display surface is 1200 mm(W) x 700 mm(L) x 800 mm(H). The display surface is a clear acrylic sheet with 10 mm thick. Hardware components of proposed system are the webcam, infrared LEDs, video projector, and tactile feedback system as shown in Figure 2. Software includes the computer vision engine, graphics engine, and tactile engine.

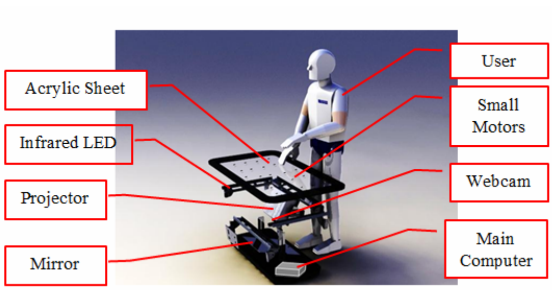


Fig. 2. System Components

For the system's vision and display, the webcam is modified for capturing 320 x 240 IR image with 30 frames/sec. Rear diffused illumination is the lighting techniques of this system with several infrared LEDs. The mirror is used for reflecting image projected from the video projector. It can increase a distance between the video projector and the display for magnifying the output image. For the tactile feedback, actuators should be small, lightweight, and low power consumption. A small DC motors as shown in Figure 3 (a) are used for generating tactile feedback to the user. Thirty motors, which are attached below the display surface, are linked together with tiny copper wires. There are 5 rows of motors. Each row contains 6 motors and the space between motors is about 100mm as shown in Figure 3 (b).

(a) (b)

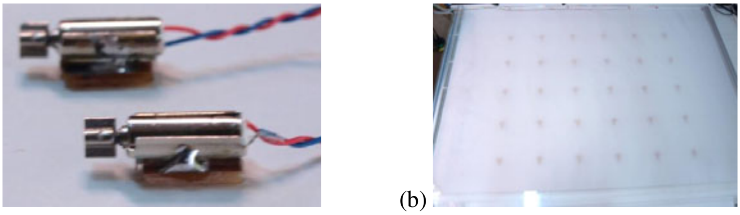


Fig. 3. (a) The implemented small DC motors. (b) Thirty motors mounted below the display.

Figure 4(a) shows the overview of a tactile controller. The tactile controller consists of Arduino microcontroller [6] and a transistor circuit implemented for driving array of motors as shown in Figure 4(b).

(a) (b)

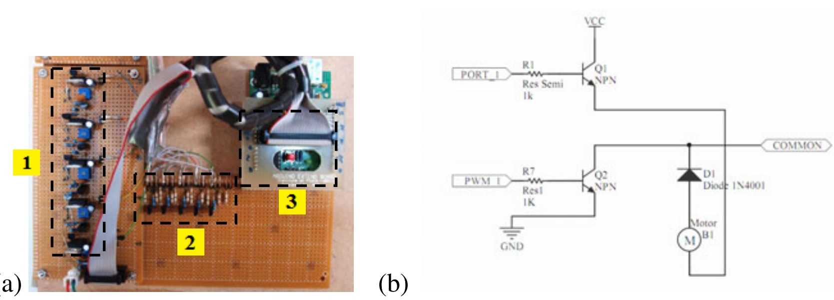


Fig. 4. (a) Tactile controller: 1) Row motor driver circuit 2) Column motor driver circuit 3) Arduino microcontroller (b) Schematic diagram of a tactile feedback driver

For the part of system software, Community Core Vision (CCV) software library developed by NUI Group Community [7] is used in the computer vision engine. The computer vision engine is responsible for detecting position of finger touch on the multi-touch display table. The position of detected finger touch is then sent to the graphics engine via the TUIO [8] protocol. It is used to trig the event in graphics engine. The graphics engine renders 2D computer graphics projected on the display surface via a video projector. The tactile engine generates the impulse response through the small motors when the user interacts with the graphics. That engine also provides multi-point vibration synchronized with the computer graphics. The user will receive both graphics information and corresponding vibration when he/she touches the screen.

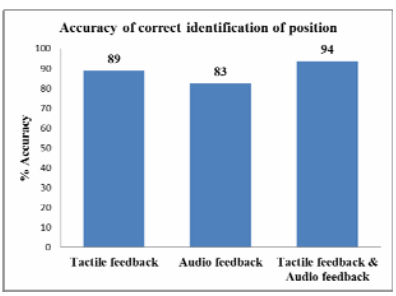
3 Experimental Results

The experiments are set for testing the system performance and usability. The system performance covers the provided ability of the system input and output. The input image which captured by the camera is 320 x 240 pixels with 30 fps. The interactive working area for input and output is a screen with 30" diagonal. The graphics update rate is about 60 fps with the image resolution of 1024 x 768 pixels. This system can track the finger touches with velocity up to 120 cm/sec and up to 50 finger touches simultaneously. The tactile feedback system can response 30 points independently. The total area which can provide tactile feedback is about 46 cm x 60 cm. The smallest interactive area with tactile feedback is about 10 cm x 10 cm.

3.1 Usability

To test the usability of the tactile feedback, the users were asked to find the 8 invisible virtual buttons with random positions on the display. The experiments are set in three conditions which are the invisible virtual buttons with only tactile feedback, ones with only audio feedback, and ones with both tactile and audio feedbacks. The number of correct positions and times used were recorded. From the results as shown in Figure 5(a), the invisible virtual buttons with both tactile and audio feedback can increase the number of correct positions with 5 percents compared to the ones with only tactile feedback and 11 percents compared to the ones with only audio feedback. Figure 5(b) shows the time used to find the correct positions of all 8 invisible virtual buttons. The operation time from the system with both tactile and audio feedback can be reduced with 49 percents compared with time from the system with only tactile feedback and 32 percents compared with time from the system with only audio feedback.

(a)



(b)

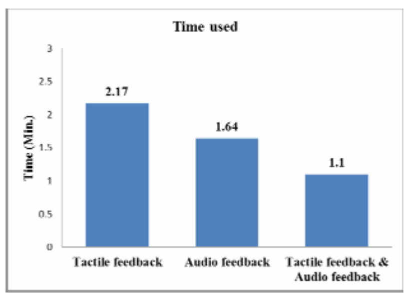


Fig. 5. (a) Accuracy of correct identification of position (b) Time used

For another experiment, the users were asked to classify the vibration level which was generated into three levels. Before doing a test, the user must learn about each vibration level. From the experimental results, users can correctly identify the high vibration level with 48 percents, the medium vibration level with 62 percents, and the low vibration level 90 percents. The user's satisfaction after using the system is evaluated through data from a questionnaire. From the results, the usability of display size got the highest satisfaction score with 78 percents. The satisfaction score of the use of the virtual buttons with tactile and audio feedback is increased by 6 percents compared with the score obtained from the use of the virtual button without tactile and audio feedback. With tactile and audio feedback, it makes the user feel like he/she interacts with a real button. The lowest satisfaction score is related to accuracy of touch detection with 66 percents.

4 Conclusions and Future Works

This research implemented the multi-touch surface table with multi-point tactile feedback. The proposed multi-touch table applied DI lighting technique for finger touch detection. The small motors which mounted below display surface are used for generating tactile feedback. From the experiment results, the tactile feedback helps user to find the invisible virtual buttons more easily and correctly. The virtual button, which provides tactile and audio feedback, helps user to feel more realistics. Various patterns and levels of the tactile feedback can be programed to increase the effectiveness of this proposed system. Furthermore, the accuracy of touch detection can be improved by adjusting the IR lights and selecting the suitable threshold for the binary image conversion. It is challenge to apply this system for entertainment applications, public relations, and computer-assisted instruction applications which the user can use them for self-learning.

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References

1. Jefferson, Y.H.: Low-cost multi-touch sensing through frustrated total internal reflection. In: Proceedings of the 18th annual ACM symposium on User interface software and technology, pp. 115–118. ACM, Seattle, WA, USA (2005)
2. Katz, I., Gabayan, K., Aghajan, H.: A multi-touch surface using multiple cameras. In: Blanc-Talon, J., Philips, W., Popescu, D., Scheunders, P. (eds.) ACIVS 2007. LNCS, vol. 4678, pp. 97–108. Springer, Heidelberg (2007)
3. Dietz, P., Leigh, D.: DiamondTouch: a multi-user touch technology. ACM, New York (2001)
4. Ivan, P., Shigeaki, M.: Tactile interfaces for small touch screens. In: Proceedings of the 16th Annual ACM Symposium on User Interface Software and Technology. ACM, Vancouver (2003)
5. Ivan, P., Jun, R., Shigeaki, M.: TouchEngine: a tactile display for handheld devices. In: CHI 2002 Extended Abstracts on Human Factors in Computing Systems. ACM, Minneapolis (2002)
6. Arduino, http://www.arduino.cc
7. Community Core Vision, http://www.ccv.nuigroup.com
8. TUIO, http://www.tuio.org