접촉 센서를 이용한 사용자 인터페이스 설계

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Designing a Touch-based User Interface System for Handheld Devices

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요 약

This paper proposes a new interaction system for portable devices that combines two different types of sensors: a set of capacitive touch sensors and an accelerometer. The touch sensing system of this device can detect multiple finger-touches and finger proximity to the surface, while traditional touch sensing systems such as touchpad usually focus on recognizing the position of a single finger. In addition, a tri-axis accelerometer is applied to measure the motion information such as the inclination angle and vibration of the system caused by a user. Combining multi-finger touch and motion information, the proposed system provides users with a game-like experience by enhancing contextual navigation and realistic manipulation.

Keyword : Touch-based interaction, Mobile User Interface

INTRODUCTION

Many users have been found to experience severe difficulties in using portable devices with limited input devices and small-sized screens. One way to reduce the poor experiences is to enhance the implicit input capabilities by making interface more realistic, intuitive, and easy to use [4]. Therefore, sensing-based user interface is at the core of fast developing areas of mobile devices including PDA, mp3 player, multimedia player, cellular phone, and so on. In this paper, we attempt to extend beyond visual user interfaces and employ relatively unexplored modalities for new interaction with mobile devices: touch and motion.

We proposed a sensory-enhanced mobile device with components of game-like experiences including contextual navigation and realistic responsiveness. Game-like features make it easy to get a feel for the navigation similar to games' real-time response to user input [5]. The proposed system can be used to provide a rich interaction with a feeling of navigation and responsiveness as perceptual immersion.

Contextual Navigation by Motion

We developed a motion-based contextual navigation system using accelerometers to provide a feel for the navigation: spatial and temporal context. The spatial context provides insight into where users could get to quickly from their current location, and temporal context helps users keep track of where they had previously visited [3]. Roll angle is used to determine the direction of spatial navigation allowing users to move one level up or down along the hierarchy form the current position. Pitch angle is mapped to temporal relationship providing time-based forward and backward navigation.

Realistic Manipulation by Touch

We implemented a touch-based intuitive control device using capacitive touch sensors to provide a feeling of realistic manipulation: multi-finger touch and clockwork touch. The multi-finger touch supports the user for scrolling up and down to see the full list of the contents and moving from page to page to view all the contents. The speed of these actions can be selectively controlled by two-fingertips touching along the both edges of the device. The clockwork touch helps users to rotate the object by moving one finger upward and the other finger downward on both sides of the disclosed portions.

Prototype system

By employing touch and motion sensing systems collectively, the proposed system can provide natural interaction by itself without additional input devices such as a mouse, a stylus, etc., whose overall structure of operation is illustrated in Fig. 1.

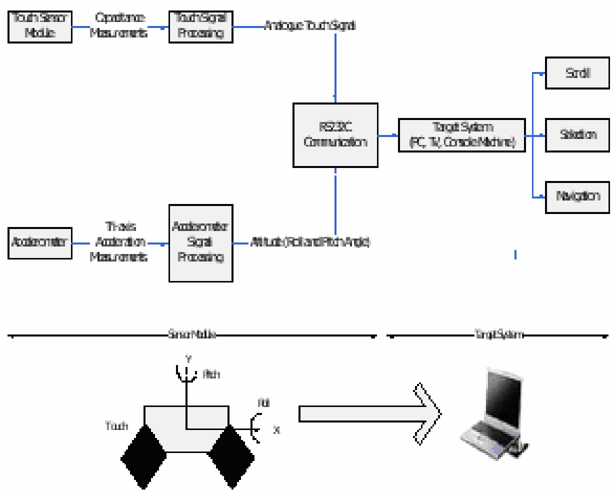

Fig. 1 Overall block diagram

As shown in Fig. 2, the touch sensing system is installed on the front panel and its resolution is 18 by 8 and the size of each touch sensing electrode is 6 mm by 6 mm. Totally 16 Motorola MC33794 electric field imaging devices [2] are employed to control 144 (= 18 * 8) electrodes since each MC33794 IC can control 9 electrodes. In addition, a Kionix KXM52 accelerometer [1] is embedded in the system to measure tri-axial acceleration which is used to compute inclination (tilting) information, i.e., roll and pitch angles. The sensing axis of the KXM52 is also depicted in Fig. 2. In the figure, the direction of arrow is defined as a positive direction.

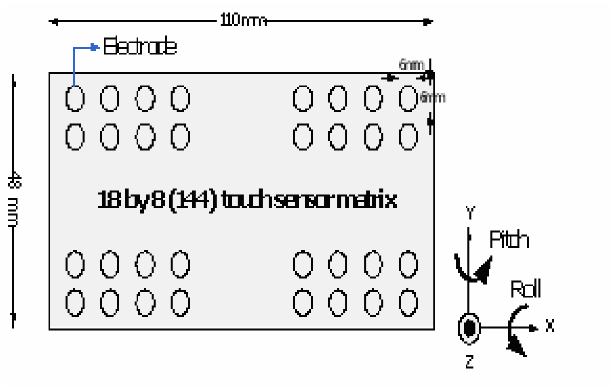

Fig. 2 Configuration of touch sensing electrodes and the accelerometer (The direction of each arrow denotes the positive angle of rotation).

Interactions

This section presents detailed interaction schemes with the proposed system.

Motion-based Navigation

The first application is the navigation of menu systems. In this example, roll (rotation around x axis) angle is used to determine the direction of spatial navigation. A user holds both edges of the system and rotates the systems along the x axis. Holding the system with both hands prohibit the system from performing unintended commands.

The upward and downward navigation is indicated by positive and negative roll angles, respectively. In order to provide users with more precise control, we define two types of different motions. The first is rotate-and-replace and the other is rotate-and-stay. The rotate-and-replace action causes the navigation discrete, i.e., the action corresponds to one-step upward or downward navigation. On the contrary, the rotate-and-stay action causes the system continuously go upward or downward along the menu hierarchy until the user releases one or both of touched portions of his/her hands from the system. Fig. 3 illustrates the motion-based spatial navigation scheme.

Besides the spatial navigation, temporal navigation is also an important component of menu navigation system. Since temporal coordinate is often mapped to lateral direction, we map the pitch (rotation along the y axis) angle to temporal navigation.

Similar to the spatial navigation, the positive pitch angle indicates the forward temporal navigation while the negative pitch angle denotes the backward temporal navigation.

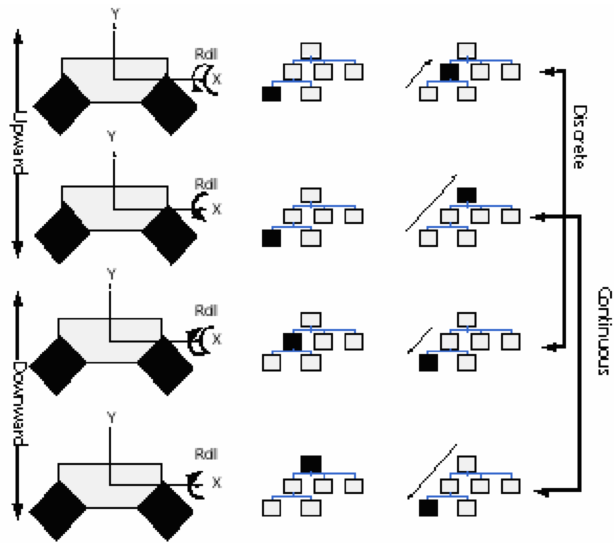

Fig. 3 Motion-based Spatial Navigation

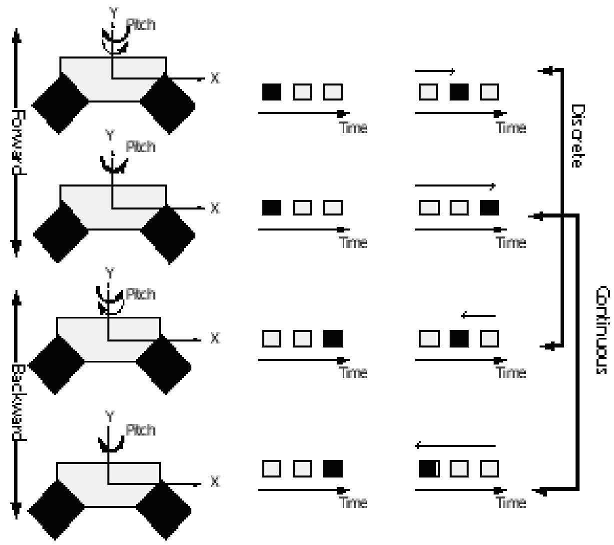

Fig. 4 Motion-based temporal navigation

Touch-based Control

The second interaction technique mainly focuses on within-page navigation, between-page navigation, and object control. In the proposed interaction schemes, we use the touch sensor as the primary source of information. For within-page navigation it is useful to take advantage of the fact that the scroll action can be selectively controlled by both hands. Therefore, scrolling a page with a normal speed corresponds to moving the fingertip only along the right edges while moving two fingertips along the both edges causes scroll speed faster. This interaction method utilizes the one of the main feature of the proposed system, so called multi-finger touch sensing. For between-page navigation, we use the lower horizontal portion of the touch sensing system. Here, left and right movements of the fingertip correspond to the next and the previous page, respectively.

Another interesting interaction technique using multi-finger touch sensing system is the rotation based on clockwork metaphor, whose concept is depicted in the bottom row of Fig. 5. The clockwork metaphor assumes that a rotary wheel (clockwork) is assumed to be hidden inside the system and only portions of its left and right edges are disclosed. Then a user rotates the virtual clockwork by moving one finger upward and the other finger downward on the two disclosed portions on both edges. There are several similar interaction methods such as the scroll-wheel in Apple's iPOD. However, it should be noticed that the proposed technique provides more free space between the two virtually disclosed touch sensing portions, which makes it more feasible for very small-sized hand-held devices. For more example, mobile phones equipped with touch sensors along the both edges of the keypad can provide rotation-based user interface without sacrificing the keypad.

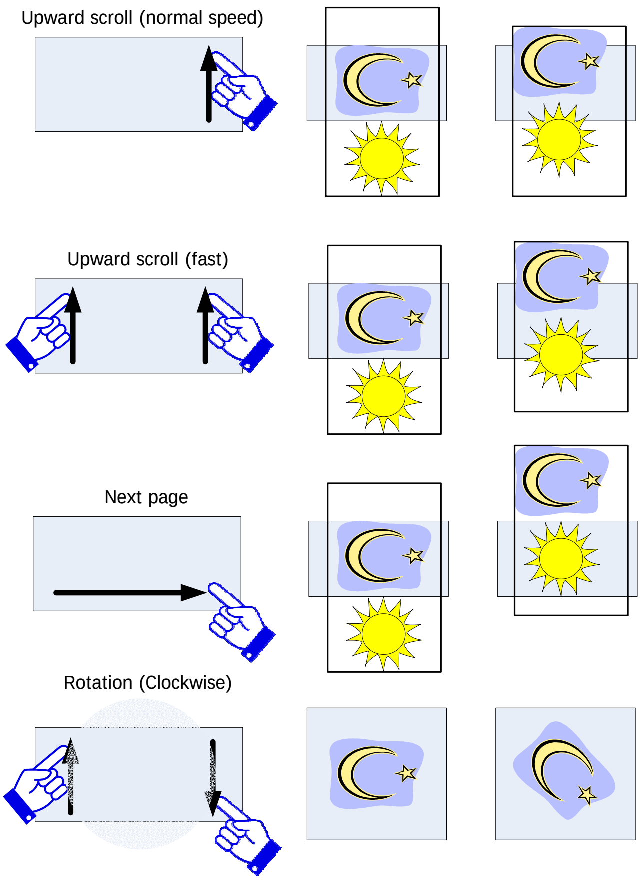

Fig. 5 Touch-based control

Conclusion

In this paper, we have described a new sensory-enhanced interface system combining touch and motion information. The touch sensing system can detect multiple finger-touches to the surface to provide realistic manipulation. The tri-axial accelerometer is applied to measure the motion information such as the inclination angle of the device to enhance contextual navigation. The proposed system helps users to experience a compelling interaction with a feeling of navigation and responsiveness as perceptual immersion.

ACKNOWLEDGMENTS

We thank all who are not included in the author list although their contributions were very important.

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