GraspZoom: zooming and scrolling control model for single-handed mobile interaction

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ABSTRACT

A pressure sensing based single-handed interaction model is presented in this paper. Unlike traditional desktop GUI model, mobile UI model has not been established yet. For example, Apple iPhone proposed "Pinch" operation, which use two fingers to zoom-in and zoom-out objects. However, in a today's hand-held situation, manipulation methods using two fingers are not always good solution because they require two hands in order to hold the device itself in most cases. We propose a single-handed UI scheme "GraspZoom": multi-state input model using pressure sensing. Force Sensitive Resistor (FSR) attached on backside of a mobile phone was employed in order to evaluate effectiveness of pressure based control model. We also describe example applications which enable intuitive and continuous zooming and scrolling. By using tiny thumb gesture input along with this pressure sensing method, bi-directional operations (e.g., zoom-in and -out) are also achieved.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Input devices and strategies

General Terms

Design

Keywords

Input devices, interaction techniques, single-handed, pressure sensing, mobile device

1. INTRODUCTION

Traditional desktop GUI operations with pointing device (e.g. mouse, touch pad, etc.) are basically designed to be used for controlling two dimensional graphics by using a device with two degrees-of-freedom input for x-y position input and one or multiple clickable buttons for selection. In addition, it is common that additional one dimensional input mechanisms (e.g. scroll wheel) is used for operation of zooming or scrolling.

In today's typical mobile hand-held interaction models, it is often difficult to achieve simultaneous input of position and additional scale value because of limitation of input devices. However it will frequently occur that changing its scale and position because of its' small size display. Thus effective zooming and scrolling control methods are highly demanded.

Recently, a lot of interaction methods are proposed to make mobile hand-held interaction more intuitively and easily. Many industrial company make consumer products which employs multi-touch interaction. Apple proposed UI scheme named "Pinch" and "Flick", which is designed for multi-touch capable hand-held device like iPhone [1]. "Pinch" is two fingered manipulation technique. When applying zooming operation, users simply touch two points and enlarge or small displayed images by changing the distance between those two fingers. This operation basically requires both hands because the user have to hold the mobile device itself by non-operation hand. Thus this method cannot be suitable for the device which is normally operated by single hand such as mobile phones. "Flick" is mainly for scrolling large image or long list objects. When users touch objects and move toward one direction, the objects go on moving as if by its inertial force. If the user wants to move the object quickly, scrolling speed is adjustable by speed at the moment of releasing a finger. However, if the list has huge number of items, users have to do "Flick" operation so many times. It seems so stressful operation when the device is used by single hand. Actually Apple provides A-to-Z index along with list for second option in order to solve this problem. Thus consensus of standard single-handed mobile interaction method has not been established yet.

Figure 1: Usage example of "GraspZoom" experimental implementation device.

If continuous and easily controllable parameter input device is available, the problem above will be solved. A lot of previous re-

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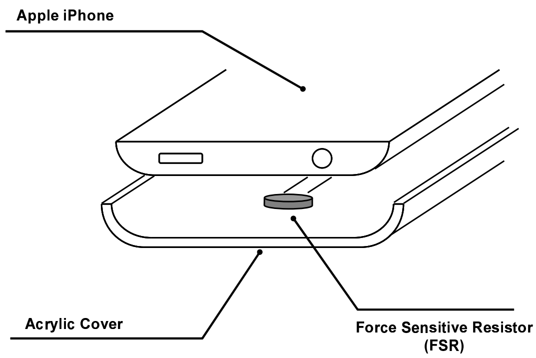

Figure 2: "GraspZoom" sensor configuration.

search investigate pressure sensing based UI, which use mouse surface [4] or stylus pressure of tablet [7] as continuous pressure sensitive input device, and users are able to adjust its pressure as well as they do in the real world. However for the mobile GUI inputs purposes, pressure sensing is not widely used. This is because sensing mechanisms such as pressure sensitive LCDs or tablets tends to be complex and require higher costs for mobile devices.

In this paper, we present a new interaction method, "GraspZoom", which enables a pressure sensing based manipulation for mobile hand-held user interaction with minimal hardware costs. Our experimental implementation uses commonly available PDA along with Force Sensitive Resistor (FSR) attached on backside of it. With this minimal modification of hardware implementation, we have investigated combination with tiny gesture input while a fingertip touches the screen of mobile devices for bi-directional parameter input.

The main contribution of this paper is single-handed interaction strategies for a pressure sensing based zooming and scrolling method. An experimental implementation for exploring pressure sensing oriented interactions for mobile environment is also provided.

2. PROPOSED METHOD

2.1 Pressure Input for Single-handed Operation

Figure 2 shows the sensor configuration setup of GraspZoom. It consists of a FSR (Interlink Electronics [2]) as pressure sensor and an acrylic cover which is attached backside of a mobile device and propagates pressure force.

FSR is in the form of polymer film, and has a variable resistance as a function of applied pressure. Capturing dynamically changing pressure values can be implemented in low cost using this sensor. This FSR and serial port of the mobile device are connected via AVR 8 bit micro-controller.

Figure 4 shows the state transition diagram of proposed method. GraspZoom has tri-state model: "Out of range" mode as idle state, "Touched" mode same as traditional touch screen input state and "Pressed" mode which is distinguished from "Touched" by threshold of pressure sensor output value. The threshold value is different depends on direction of changing state in order to prevent unstable "chattering" conditions. This hysteresis threshold value makes operation stable even in mobile environment.

GraspZoom UI uses combination of conventional position input from touch screen and this additional continuous parameter control

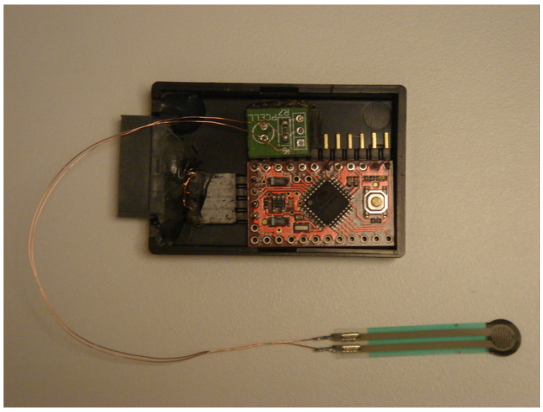

Figure 3: GraspZoom sensor device. (FSR and serial port of Apple iPhone are connected via AVR 8 bit micro)

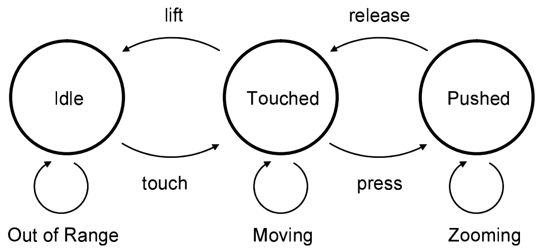

Figure 4: Interaction state diagram of GraspZoom.

from pressure sensing. "Pressed" state and its actual values from sensors are mainly used for changing continuous parameter such as zoom scale or scroll operation.

2.2 Combination of Pressure Input and Tiny Gesture on Screen

Pressure based interaction, for example zooming and scrolling, requires control of scale parameters in two directions (zoom-in, -out or scrolling-up, -down). Thus intuitive mode switching operation is important for applications of GraspZoom. We employed combination of pressure input and tiny thumb gesture input on the screen to achieve this bi-directional zooming and scrolling operation. The gesture motion can be sensed by touch screen of the mobile device. Although there is another possibility to sense tiny gesture on backside of the device, from our preliminary observation, gesture input on backside is too difficult to manipulate by single hand.

2.3 Usage Examples

GraspZoom could be applied to various finger-tip operation for mobile hand-held interaction, such as zooming photos, scrolling lists, drag-and-drop emulation, visual assistance of software keyboard. Some examples of how GraspZoom works are described in this section. Figure 5 shows interaction style notation used in this section in order to describe state of manipulation.

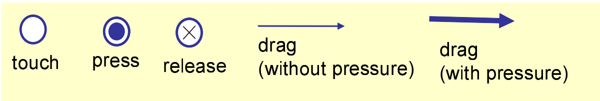

Figure 5: Interaction style notation

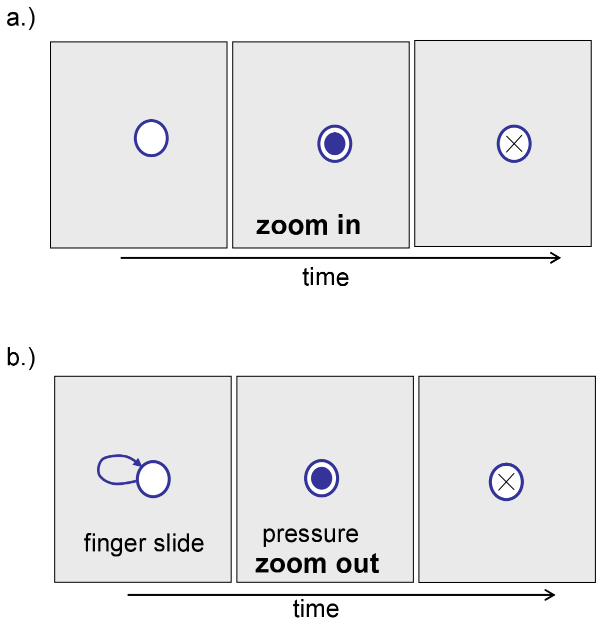

Figure 6: Operational state of zooming interaction. (a: zoom in , b: zoom out)

2.3.1 Zooming

Users wants to temporarily zoom-in or zoom-out more often in mobile hand-held situation, because physical size of screen is limited and cannot see entire figures and details at the same time. Thus intuitive and smooth manipulation method of changing scale parameter is important for mobile devices.

Using a conventional interface, zoom-in and zoom-out are separate commands, and users have to change modes (e.g. “loupe magnifier” from tool palette). *Pinch*-in and -out operations of iPhone which needs two hands are not always suitable for single-handed operation under mobile situation.

Our technique enables users to controlling zooming parameter smoothly with continuous visual feedback while using single hand. Figure 6 describes state diagram of zooming interaction. On zoom-in operation, the users simply touch and press where they wants to magnify as shown in the Figure 7. Asymmetric hysteresis threshold of state transition (“pressing threshold” and “releasing threshold”) enables stable operation. On zoom-out operation, we have employed combination of tiny sliding gesture on screen before pressing the screen. If the sliding operation on touch screen is sensed in the state of “(b). Touch”, zooming direction in “(c). Press” is changed to zoom-out. In this way, bi-directional parameter input is possible with GraspZoom.

2.3.2 Scrolling

Scrolling is second most important operation for today’s mobile devices. Because of huge storage size in mobile devices, there are a lot of situations to select an item from long scrolling list (e.g., address list or music playlist).

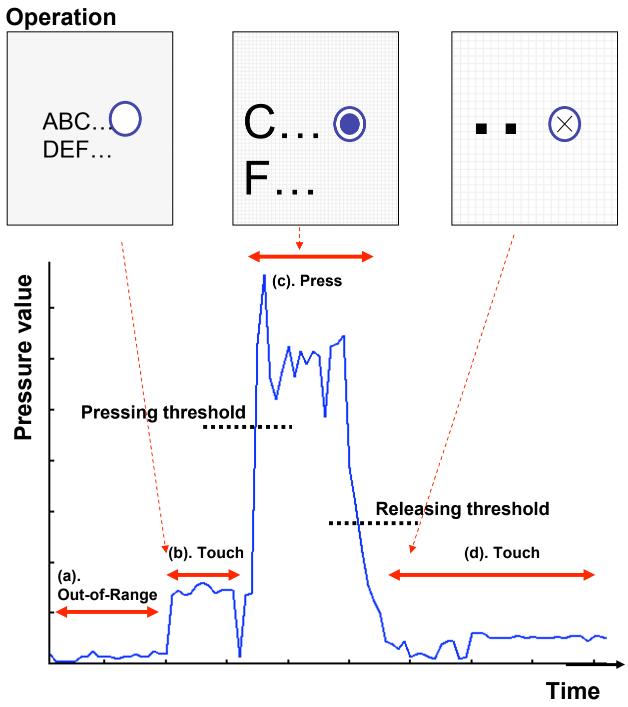

Figure 7: State diagram and pressure intensity of zooming interaction.

Figure 8 shows state diagram of scrolling interaction. In this case, position of pushing determine the direction of scrolling. Moreover, the users can change direction the other way using tiny thumb gestures sliding before pressing the screen similar to zoom-out operation in previous example.

Our proposed method enables a user to scroll continuously using single long pushing operation while conventional method (e.g., flicking or button pushing) requires multiple time operation relative to demanded amount of scrolling. This is a significant difference in usability for single-handed user operation.

3. DISCUSSION

Our implementation design provides the opportunity to explore example applications and to observe people using it. From this observation, we were able to find several other design spaces to possibly accomplish the task. In this section, a set of possible options and its feasibility are described.

Sensor configuration In our implementation, pressure sensor was attached to back-side of mobile devices. However this could be second-best solution in order to use commonly available mobile device for our exploring. Force sensitive touch screen device is also possible of course in the future. However this is a subtle implementation problem, because it is enough to be able to sense position of a fingertip and its pressure value simultaneously.

Interaction state model There are other design spaces for triggering desired zooming or scrolling interaction, for example a number of tapping, variation of gestures before pressing or tactile feedback.

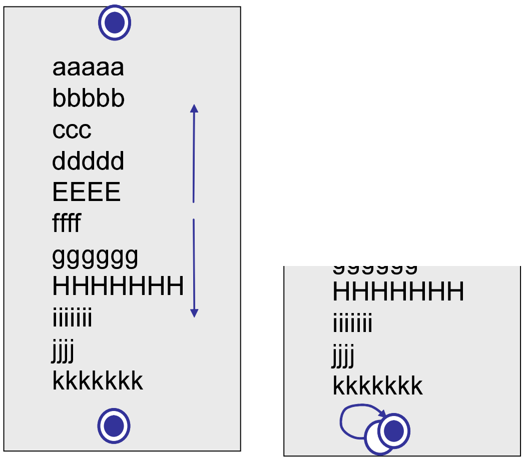

Figure 8: Operational state of scrolling interaction.

Sensing modality Pressure sensing is one of feasible solutions for making additional continuous parameter of course. However, stability of pressure intensity can be a problem for consumer products. Another possible option is utilizing contact area of a fingertip as an pseudo pressure values in place of using actual pressure sensors.

4. RELATED WORK

Ramos et al. proposed generalized pressure based UI frameworks for pen tablet [6]. Their main focuses are continuously changing pressure values and its visual feedback. Blaskó [3] proposed a single-handed pressure sensitive user interfaces. Multiple pressure sensitive touch pads are used for controlling multiple parameters. Although these are effective for desktop environment, it is difficult to apply single-handed interaction with mobile devices.

Rekimoto et al. proposed PreSenseII [8], which enables bi-directional pressure sensing interactions with tactile feedback. By sensing contact area from touch pad, this method can distinguish between positive pressure and negative pressure finger pose. Although this works well in desktop environment, it has been still difficult to use in mobile hand-held device because of its sensor and actuator configuration in layer structure.

HybridTouch [10] explored a mobile interaction which uses behind side of mobile devices for using input areas. Wobbrock [11] employed gesture input using joystick in place of button pressing in order to input text messages. Both approach are possible solutions for mobile hand-held user interaction problem which user cannot see the display while manipulating because of self occlusion by a user's hand. However there seems to be too complicated for ordinal use case such like browsing or scrolling.

Common strategies to facilitate continuous parameter input by using pressure sensing are also proposed [5][9]. These approaches take basically same strategies for multi-level interaction model while pressing the device. However only multi-level interaction is still not enough to accomplish continuous one dimensional parameter control, because the operation of switch direction is needed in most applications.

In our approach, we combined these multi-level pressure sensing and tiny thumb gestures on screen in order to achieve bi-directional parameter controlling, that is important for mobile device which have to be controlled in single hand. Additionally, our proposed configuration requires minimal hardware modification to today's mobile devices, and can effectively perform pressure sensitive single-handed interactions.

5. CONCLUSION

In this paper, we introduced the concept of GraspZoom, a pressure sensing based interaction techniques for single-handed operation with mobile devices. We have presented operational models for pressure based input devices that aims to support mobile small screen interaction. The prototype system which composed of consumer PDA and FSR was used for exploring its design space of interaction technique. Usage examples of continuous zooming and scrolling operations are also shown with operational state model. Asymmetric hysteresis threshold of state transition was effective to stabilize mode change operation. In order to achieve bi-directional zooming and scrolling, combination of pressure sensing and tiny gesture of sliding a fingertip before start pressing. Thus it is confirmed that intuitive direct operation of zooming and scrolling can be realized only minimal hardware modification of commercial mobile devices. Future work must include application design and quantitative evaluation in order to judge its effectiveness of performance.

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