Augmenting Tactile Interaction with Pressure-Based Input

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ABSTRACT

The application of pressure (or force) through the fingers is an inherent part of investigative and interactive touch and yet remains underutilized in the field of Human Computer Interaction (HCI). To highlight the potential usefulness of pressure as an input or information channel, this paper includes example implementations and uses for pressure-based input in a variety of domains. These include the active application of force for the purposes of interacting with or controlling devices as well as passive detection of force as a means of monitoring behaviour in safety or healthcare scenarios. The use of pressure would allow for easier, more varied and more engaging interaction with devices, providing opportunities for new applications and services to be developed beyond what is currently possible.

Categories and Subject Descriptors

H.5.2 User Interfaces: Haptic IO

General Terms

Design, Human Factors.

1. INTRODUCTION

All muscle contractions are divided into two categories: isotonic and isometric. Isotonic contractions manipulate movement (e.g. extending an arm) and isometric contractions manipulate tension (i.e. force or pressure when squeezing/pushing). Both are necessary for interaction with the environment, as we need to move towards and reach out for an object but also pick it up. The application of pressure/force through the fingers, and thereby the testing of compliance, is one the fundamental "investigative procedures" in object interaction [4]. Our ability to apply force is precise but also wide-ranging, as we can pick up an insect unharmed in our fingertips but we can also sumo wrestle. However, HCI makes markedly better use of isotonic/pointing contractions than isometric/tension contractions. The desktop mouse, laptop trackpad, kiosk/phone/tablet touchscreen, Wii Remote and Kinect hand/arm gestures are all examples of isotonic interactions. Isometric interactions require devices that can detect and withstand applied pressure.

Pressure/force application is most often based on motionless (isometric) sensors, such as the tip of a graphics tablet stylus [6] or a Force-Sensing Resistor (FSR). FSRs are small, flat pads that measure the amount of force applied to their surface and have been attached to the sides/top of a desktop mouse [2], under a touchscreen [5] and on the body/bezel of mobile devices [7] for the purposes of device interaction. The results from a growing body of work are increasingly supportive of the use of pressure in HCI, highlighting precise control in a variety of tasks and situations, even when mobile [1, 6]. A key benefit for pressure input is its applicability to mobile interaction, as mobile devices have more limited input channels compared to desktops. As we already hold our phones/media players in our hands, it is logical to make more use of grip as an input channel.

There are many potential examples of how pressure can be integrated into commercial and professional systems for the benefit of control, experience or welfare. This paper will give brief examples of both existing and future applications of pressure, detailing the potential advantages the incorporation of pressure input could bring to the system, creating compelling new interactions and opening up new avenues for service and application consumption. The examples are broken up into those involving active input from users for deliberate system interaction and those involving passive input for behaviour detection.

2. ACTIVE INPUT FOR CONTROL

2.1 Personal Electronics

Consumer electronics, particularly personal media devices such as phones, media players and tablets are almost universally moving towards interaction paradigms based on touchscreens and 2D/3D physical gestures. The use of pressure as an additional input channel sits as a natural augmentation to these increasingly physical interactions. Force-sensing resistors (FSR) could be placed under touchscreens to augment typically 2-dimensional (i.e. x-y) touch with a 3^{rd} (z) dimension. This could be used to add false physicality/travel to virtual buttons or for moving in the 3^{rd} dimension (into/out of the screen) in emerging 3D interfaces.

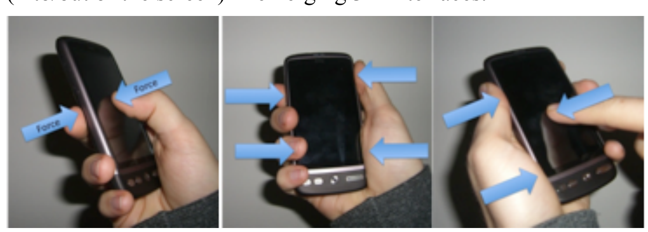

Figure 1: Potential pressure sensitivity locations on mobiles.

Alternatively, force sensors could be placed around the body/case of the device away from the screen. Common touchscreen gestures such as pinching to zoom and flicking to scroll could be replaced with pressure-based alternatives. Pinch gestures most often require two fingers be placed on the screen, which then obscure the very content that is being looked at. This gesture also requires two hands: one to hold the device and one to pinch. Flick-based scrolling can be done one-handed, but if the document being scrolled is longer than two or three screen heights, multiple flicks or swipes may be necessary to reach the bottom. Pressure-based alternatives could improve these interactions by replacing touchscreen interaction with squeezing the sides of the device. For zooming, the user could control the level of zoom by the amount they squeeze, allowing for one-handed control of zoom. For scrolling, the scroll speed would be controlled by the amount of force applied, with the speed increasing as force increases. These would also leave the screen free of obstructing fingers and give continuous and fine-grained control over the onscreen movement.

A small body of research is building which suggests that pressure input on personal and mobile devices is highly precise for particular applications such as menu navigation and text entry [1]. Even when the user is walking [7] and being provided with only audio feedback [7] interaction with menus up to 10-items in size remained highly precise. In this case eyes-free control of touchscreen devices when walking is now feasible (something that is currently difficult due to the flat featureless nature of touchscreens) simply by squeezing the device and using stereo earphones for feedback. The success of Apple's iPhone is due in no small part to its novel (at the time) touch interface and so the value in novel and interesting interaction channels is clear.

2.2 Vehicles

To improve the ease of access/operation of in-vehicle systems, controls for the stereo, climate control, displays etc. have moved from the dashboard to the steering wheel/column. However, these controls may still require the driver to alter his/her grip and/or move the hands away from an optimal position and also shift visual attention from the road to the steering wheel. Augmenting the steering wheel with force-sensitivity would allow drivers to control certain features without altering their hand position or focus of attention; they would simply need to squeeze a target amount. Precise application of force may be difficult, as turning the wheel will require changes in the level of grip. However, a small number of simple pressure "gestures" could be enacted, such as a single, sharp squeeze could pause the music playing, and a double-squeeze could skip to the next track. A longer continuous squeeze could turn the music off. Primarily, the benefit of this novel input method would be to improve safety for drivers, however it also provides new and interesting experiences for the driver, and, by removing buttons, may free up extra space in the cabin for design teams to repurpose.

3. PASSIVE INPUT FOR DETECTION

3.1 Security

In 2009 Microsoft demonstrated a desktop keyboard whose keys were augmented with pressure-sensitivity [3]. An example application made use of this feature to improve password protection through biometric analysis, by not only taking the keys pressed into account but also *how* they were pressed: how hard, how quickly they were pressed and released, and the time between key presses. The developers were able to show that this pattern was unique to the individual. Regarding e-commerce, even with the victim's login details, card and PIN a thief would be unable to access sensitive information without the user's unique biometric pressure pattern. Similar measures could also be taken with Chip & PIN terminals or mobile phone PIN/gesture lock mechanisms, thereby increasing security, decreasing the number or frequency of fraud incidents and saving costs associated with fraud.

3.2 Healthcare

Passive pressure-sensing around the home could be used to help identify whether an individual is at risk of developing, or has already started to develop, certain motor control problems. Sensors attached to commonly used items like cups, cutlery or door handles would be able to measure grip patterns over time, including strength and force distribution, and be able to relay this information to the individual's GP to give an early warning of decrease in grip strength or drop in dexterity. Sensors in footwear could monitor weight distribution over time to identify changes in weight and signs of balance and movement problems. This type of monitoring is somewhat invasive in terms of privacy, however, so there are ethical and personal considerations that would have to be taken into account.

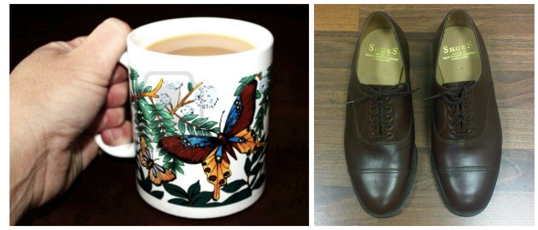

Figure 2: Sensors around the home could detect deteriorating motor control or balance in those at risk.

3.3 Vehicles

Whereas active pressure input on a steering wheel may be possible for simple tasks, passive detection of grip could also be employed, possibly in conjunction with other sensors, for safety purposes. A basic example would be if no force is detected on the steering wheel when the car is in motion, indicating the driver has let go of the wheel, when a warning could be given, possibly via audio feedback. If the driver is falling asleep, but his/her hands remain on the wheel, monitoring of their grip may give indications of over-relaxation resulting from loss of consciousness. A driver's grip on the wheel will vary over time when he/she is fully awake and in control, and so these signs may be hard to pick up in isolation, but taken in conjunction with eye- or head-tracking may provide more robust identification.

The example applications listed here constitute only a small selection of possible uses for pressure in consumer electronics. They offer new ways of engaging and connecting with users that are not currently possible and so offer great opportunities for capitalisation in a digital economy moving more and more towards touch and physical interaction.

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