Deformable Interactions to Improve the Usability of Handheld Mobile Devices

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ABSTRACT

Handheld mobile device use is dominated by touch interfaces; keyboards and other physical inputs are disappearing. In parallel, there is a trend towards more sophisticated devices supporting complex use. While touch devices are usable, the user experience is not optimal for all people or across all tasks. Augmenting touch devices with deformable interactions can support usability. I identify open research questions: how to pair deformation and touch, what are design questions for augmented devices, and what benefits they can provide to people? I outline work to date, highlighting a deformable mobile phone case.

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CCS CONCEPTS

• Human-centered computing~User centered design; Interface design prototyping; Mobile devices

KEYWORDS

User Interface; Multimodal Interaction; Tangible; Deformation; Embodied feedback.

Deformable devices can change shape on their own or when manipulated by a person.

Deformable Interactions include bending, squeezing, stretching, or twisting to change the shape of a device as a method of input.

They require less precise motor control than touch and feedback is an inherent and tangible element of interaction, but they constrain how devices can be held.

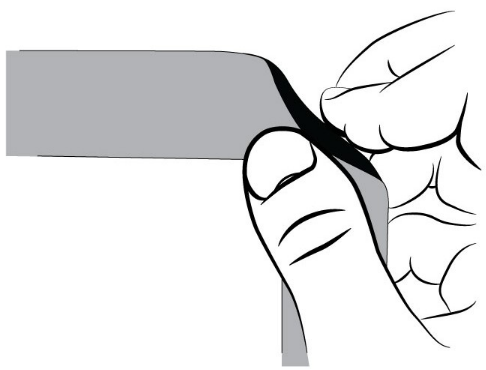

Figure 1: Bend as device input.

INTRODUCTION

Handheld mobile devices have a strange evolutionary history. As mobile phones have become more powerful and feature rich their forms have also evolved: numeric keypads gave way to QWERTY keyboards, interaction supports like styli and scroll wheels emerged, and screens became larger and more detailed [7]. Then with the advent of touch screens, a trend emerged of reducing the methods and complexity of interaction for mobile devices [4,7]. Currently, there are few inputs outside of touch [4]. Touch gestures are simple for most people, and rely on software UI, prediction, and context to infer user intent. Concurrently, mobile devices have become more powerful and support growing body of diverse uses. For some, mobiles now serve as their primary or sole personal device [10]. Mobile devices have grown in power and sophistication, but their interfaces have, in some ways, stagnated.

This issue of interface has drawn the attention of researchers; touch has shortcomings, like fat fingers, poor edge interactions, and crowded interaction space that impede its usability [1,2,3,8]. These issues are aggravated during complex tasks that require precision [3] and may be more pressing for people with impairments to dexterity [11].

Interventions that aim to increase the usability of handheld mobile devices must consider the dominance of touch and its influence on the design of mobile applications. With flexible displays emerging in commercial mobile devices [4], deformable interactions (see sidebar and Figure 1) can augment touch in contexts where usability issues persist.

RESEARCH QUESTIONS AND METHODS

I have identified three broad research questions that relate to augmenting handheld touch-interface devices with deformable interactions.

R1 – What are the design considerations for deformable interfaces that augment handheld touch devices?

R2 – How can deformable input pair with touch input?

R3 – What benefits can deformation offer, if any, to touch devices? E.g., avoidance of repetitive stress injuries, increased accessibility.

I employ rapid prototyping methods and work iteratively through low-fidelity paper and foam concepts towards hi-fidelity functional prototypes. I employ design and ethnographic methods to ideate and refine ideas, uncover usability issues, and to capture insight and domain knowledge from experts and lay persons. In usability studies, I employ both qualitative and quantitative methodologies as evaluation tools.

Figure 2: A deformable interactive device, BendAide, that fits around a mobile phone. It uses bend interactions to provide alternative controls during complex tasks like text manipulation.

RESEARCH METHODS AND PROGRESS TO DATE

In a study of one-handed use of a bend interface mobile device [8], we found that how a deformable device is held is integral to its usability and that there are open questions in the literature surrounding how holding is considered in the design of deformables.

To understand this further, I surveyed and analyzed the literature on deformable mobile devices to better understand how holding informs deformable device design and research. I found variety in the holding patterns, e.g., two-handed grips that allow free movement of the thumbs, or single-handed holds that encircle the device. Problematically, there is little discussion of holding in the design or results of studies.

It is unclear if researchers and designers are replicating the holding of rigid devices, devising new holds, or allowing new holding patterns to emerge in usability studies. This gap remains unexplored despite the importance of holding to deformable interactions.

Following this survey of holding and using insights from my previous work [5,8] I devised a deformable interactive phone case, BendAide, Figure 2, to augment touchscreen mobile devices, inspired by Fares et al.'s Paperninja [6]. In this work, we diverged from previous research [e.g., 5,6] by envisioning how bend and touch interactions might work together in complex mobile tasks, i.e., text manipulation. BendAide allows deformable input through bend gestures performed on the case's bezel and touch input on the device display. Initially we worked with low fidelity materials to work through basic device shape and interaction concepts before 3D printing and assembling a functioning prototype. The rapid production speed of 3D printing allowed the exploration of variations in shape, thickness, and fill to optimize the feel and performance.

How the device is held is a key aspect of the design of the prototype and the interactions; my aim is to work within the constraints of how people typically hold and use their smartphones during tasks that require complex interactions (e.g., precision targeting, multi-step or compound gestures). BendAide is held in portrait orientation with both hands. The user's thumbs are positioned to access a touchscreen. This follows how most people hold their smartphones during use [9]. To test how bend and touch interactions are suited for text manipulation and to gauge the potential of using both together, I devised a study comparing exclusively bend, exclusively touch, and mixed input text manipulation tasks (e.g., select, copy, and paste text). Bend performed similarly to touch but people prefer each at different stages of their tasks. Participants prefer touch for actions like scrolling through text, but felt bend provides more precision when targeting with the caret (in-text cursor).

REMAINING RESEARCH

My research to date focuses on my first two research questions: (R1) How to design deformable interfaces that augment handheld touch devices and (R2) how can deformable input pair with touch input? These questions need more attention and subsequent works can develop the design and usability considerations for deformable interfaces paired with touch.

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The qualitative feedback from the BendAide study revealed the potential of bend to make touch devices more usable for those who struggle with touch interactions. Several people struggled with touch because of dexterity and software knowledge limitations, but felt they had more control with bending after only brief use. I will explore this further by conducting co-design sessions with ergonomic experts, physiotherapists, accessibility advocates and lay-persons to design new deformable devices to work with smartphones and other handheld touch devices. I will use the insights and design considerations already gathered to guide the sessions and leverage the domain expertise of the participants. This will lead to designs that can better support daily use or that can target specific needs or task scenarios.
This will allow me to probe (R3) the benefits of augmenting touch devices with deformation, particularly for long and complex tasks. Following the co-design sessions, I will construct refined prototypes that can be distributed to people for extended use, to see if their usage habits change (i.e., do they adopt deformation) and if there is any benefit to users from changing usage patterns. For this I will rely on quantitative data, like tracking bend use vs. touch, and qualitative methods like diaries and surveys.

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