JoyHolder: Tangible Back-of-Device Mobile Interactions

Figure 1. JoyHolder as back-of-device interaction (top), phone stand (center) and phone holder (bottom).

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Abstract
One-handed mobile use, which is predominantly thumb-driven, presents interaction challenges like screen occlusion, reachability of far and inside corners, and an increased chance of dropping the device. We adopt a Research through Design approach around single-hand mobile interaction by exploring a variety of back-of-device tangibles (including a touchpad, scroller, magnetic button, push button, slider, stretchable spiral and a ring joystick). The latter 'joy'-stick was inspired from the recent popular but passive ring phone 'holders', which we combined into 'JoyHolder' – a joystick-based interactive phone holder for tangible back-of-device input interactions. We demonstrate our low-fidelity and medium-fidelity prototypes (using crafting and digital fabrication methods) and our interactive JoyHolder to encourage discussion on tangible back-of-device interactions. Preliminary insights from a pilot-study we ran reflects the hesitation for adopting some of these tangibles, the potential of others and the importance of physical feedback while using back-of-device input modalities.

Author Keywords
Single-Hand; Mobile; Back-of-Device; Joystick.

Introduction
Currently, touch-based interaction is the dominant mode of mobile-interaction [4] with single-hand use being the most common [6,9]; the other hand often occupied with a task or holding other objects. During

Figure 2. Low-Fidelity touchpad BODI prototype.

Figure 3. Low-Fidelity push-buttons BODI prototype

Figure 4. Low-Fidelity prototype using a sliding magnetic button.

single-handed use, the thumb is frequently used for input [7] which can make it difficult to reach all areas of the screen [2] and to maintain a stable grip [5]. Furthermore, thumb-use aggravates the “fat fingers” problem of screen occlusion [1,2]. Back-of-device interactions (BODI) can address these issues. Relocating interactions to the device rear avoids screen occlusion without affecting performance [14] and can also negate issues of reach and repositioning [11]; offering stability over single-handed touch use.

Commercial products, such as phone holders shaped like knobs and rings are gaining increased popularity for providing comfort and safety by serving as an anchor on the device rear. Though, attached holders like these could interfere with proposed methods of BODI. However, these phone holders could themselves be employed for interaction. We propose back-of-device interactions through phone holders that act like joysticks, allowing both firm holding and tangible input.

Related Work

Previous research shows that touchpads provide accurate, fast, and stable BODI [11,12,14]. Studies [6,14] found touchpad BODI, with the index finger, can outperform thumb interactions on the front, both in accuracy and speed. Löchtefeld et al. [11] show that BODI ensure accurate and safe input compared to one-handed touch interactions because they remove the need to reach and reposition. LucidTouch [12] employs pseudo transparency with BODI to control applications on mobile phones. It reduces occlusion, offers higher precision and supports multi-finger input. However, touchpad BODI lack embodied feedback and features like pseudo transparency require bulky peripherals. Others, like LensGesture [15] and MoCamMouse [3], rely on the rear camera for interaction, which limits their use.

Back-of-device joysticks offer an alternative [10,13] to keypads, with benefits like eyes-free use, though with some speed reduction. Tangible inputs off the screen provide embodied feedback, clearer affordances, and a broader range of interactions [8]. There are further opportunities in BODI that research can explore in terms of input forms and interaction modalities.

Exploring BODI and Designing JoyHolder

To address this gap, we adopt a research through design methodology [16] and iteratively explore the different opportunities and potential designs of BODI tangibles. In parallel to our design research, we piloted a study with HCI practitioners to gain insights on which designs to discard, alter or develop further. Our designs explored various input modalities through creating different shapes, sizes and locations of BODI tangibles. Our initial forms were inspired by previous work and our observation of single-handed mobile interaction behavior. We purposely relied on off-the-shelf sensors and electronic components to produce accessible technology and tools. The BODI tangibles we designed include stretchable sensors, sliders, spring-based buttons, magnetic buttons, cylinders, push buttons, scrollers and joysticks. Some of which were low fidelity prototypes (Figure 2-6) using crafting materials (e.g. cardboard, felt and duct tape), which opened up a design space for exploring a range of ideas. We then utilized digital fabrication methods (e.g. 3D modeling and 3D printing) to create medium fidelity prototypes (Figure 7-9) embedded with off-the-shelf electronic components to support interactivity. We explored these

Figure 5. Low-Fidelity cylinder-based BODI prototype.

Figure 6. Low-Fidelity spring-based BODI prototype.

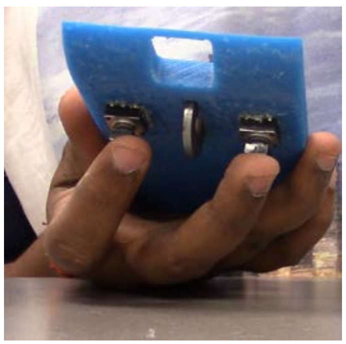

Figure 7. Mid-Fidelity mouse-based BODI prototype.

medium fidelity prototypes with HCI researchers to test their feasibility, affordance and ergonomics.

Finally, we refined our most promising prototypes, i.e. isometric and lateral joysticks, using 3D printing to create more optimized forms for BODI. This process led to the design of JoyHolder (Figure 1) the tangible BODI which lends interaction to the functionality of non-interactive phone holders, supporting both vertical and horizontal movements in addition to button-based targeting while providing an anchor for holding.

Preliminary Findings

Our exploratory design research is complemented by preliminary user feedback that informed our design decisions. We took observations and notes as our 7 participants (4 females and 3 males) provided their feedback while they held and used each prototype. Although our initial designs addressed problems of touch such as occlusion, reachability and repositioning, some BODI tangibles introduced new usability challenges, like false activations or fatigue.

False Activation and Physical Exertion

Some BODI tangibles that we designed, such as the touch plate (Figure 2) and magnetic button (Figure 4), appear susceptible to false activation. During our pilot study, one person commented “I am touching it even when I do not want to interact. As it occupies my single hand resting position and always touches my index finger.” In this sense, some BODI tangible may cause false activations doubling as supports for holding.

Comfort and Ease of User Control

Other forms, namely the cylinder-based (Figure 5), spring-based (Figure 6) and the mouse’s scroll wheel (Figure 7) revealed issues of ease and fatigue. The cylinder BODI was difficult to control, while the scroll wheel, required an uncomfortable circular motion of the index finger on the device rear which was possibly tiring after prolonged use. This motion was preferred less both in terms of tangible feedback and ease when compared to the joystick interactions. However, the initial joystick was reported to be bulky in size and difficult for the index finger to manipulate. As participants in the pilot study expressed how the joystick provided the best control, we chose to explore joysticks further.

Potentials of JoyHolder

To seize the opportunity that our joystick prototypes showed, we developed further variations in their shape and point of interaction (mount location). Informed by previous work [10,13], we positioned our ring JoyHolder and employed an angled orientation to support comfort and ease of use. To address struggles, we saw in the study, we developed our joysticks with rings to cup the finger during interaction, reduce the force needed to maintain contact and facilitate sideway movements. For comfort, we 3D-printed a ring (ø=16mm) using flexible filament, with a small gap to accommodate for different finger sizes (see Figure 1). We used two different types of joysticks: a rotational joystick (a gaming joystick in the form of a two directional analog navigation sensor with an inbuilt push button) and a lateral joystick that uses a mini-translational joystick with an added push button. Our findings show how JoyHolder supports interaction, offers an anchor for gripping (like phone stands and holders) and the ring-based design supports navigation in all directions in parallel to the multi-touch screen.

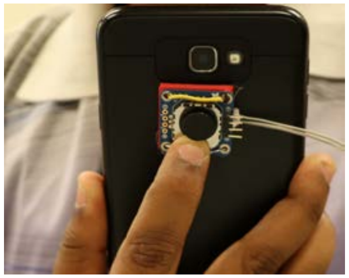

Figure 8. Mid-Fidelity lateral joystick BODI prototype.

Figure 9. Mid-Fidelity rotational joystick BODI prototype.

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Conclusions and Future Work

In our exploratory research, we designed an array of BODI tangibles to address current single-hand mobile interaction struggles. Still, while addressing issues in touch, many of our designs generated new challenges. Our most promising results led to the design of JoyHolder prototypes that supported alternative back-of-device interactions during single-handed mobile use. Further work is required to validate the usability of JoyHolder and to identify useful contexts for tangible back-of-device interactions.

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