Reflective Haptics: Haptic Augmentation of GUIs through Frictional Actuation of Stylus-Based Interactions

Fabian Hemmert[1], Alexander Müller[1], Ron Jagodzinski[2], Götz Wintergerst[2], Gesche Joost[1]

[1] Deutsche Telekom Laboratories
Ernst-Reuter-Platz 7
10587 Berlin, Germany
{fabian.hemmert, a.mueller, gesche.joost}
@telekom.de

[2] HfG Schwäbisch Gmünd
Rektor-Klaus-Straße 100
73525 Schwäbisch Gmünd, Germany
{goetz.wintergerst, ron.jagodzinski}
@hfg-gmuend.de

ABSTRACT
In this paper, we present a novel system for stylus-based GUI interactions: Simulated physics through actuated frictional properties of a touch screen stylus. We present a prototype that implements a series of principles which we propose for the design of frictionally augmented GUIs. It is discussed how such actuation could be a potential addition of value for stylus-controlled GUIs, through enabling prioritized content, allowing for inherent confirmation, and leveraging on manual dexterity.

KEYWORDS
Friction, touch screen, stylus, haptic display, physicality

ACM CLASSIFICATION KEYWORDS
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

GENERAL TERMS
Design, Human Factors

INTRODUCTION
A particular property of the graphical user interface (GUI) is its flexibility in the degree and kind of realism. Recent developments, including graphic tablets, touch screens and 'multi touch'-capable surfaces, also increase the *directness* of graphics-based interaction. Tangible user interfaces (TUIs) may provide the conceptual basis for taking this directness one step ahead, but, due to physical restrictions, these are often limited in their expressional versatility.

Merging the two of them, however, might be a worthwhile undertaking – it may add more realism to GUIs, and more expressive versatility to TUIs. Their mappings and links are yet to be explored, and so a set of real-world object properties, which is currently underrepresented in GUIs, will be discussed in this paper: mass, gravity and friction.

BACKGROUND
In the past, frictional simulation and actuation have been of growing interest within the HCI community.

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Fig. 1.: Stylus and GUI, displaying stickiness-augmented newsreader (a), resistive signature field (b) and rubberized grid lines (c).

Simulating physical properties can help making interactions with digital contents more intuitive. Endeavours in this area include, for instance, Agarawala and Balakrishnan's 'Bumptop' [1] and Wilson et al.'s 'Physics to the Surface' [13]. Such research demonstrates the potential richness that a natural style of interaction can offer. At the same time, these approaches do rely on solely audiovisual cues – using haptic cues, consistent to the physical entities simulated on-screen, might add to the experience.

Placing tangible items on a screen can make the interaction more rich and intuitive, as demonstrated in Weiss et al.'s 'SLAP Widgets' [12] and Terrenghi et al.'s work on physical handles on virtual surfaces [11] and explorations on pressure-based input by Ramos [10]. Still, these approaches are based on tangible input, lacking haptic feedback – added force feedback might worth investigating.

Haptic feedback in pen-based interactions, as investigated by Lee [6], Poupyrev [9], and Forlines [3], has shown that styli can be successfully augmented with actuators, providing users with a richer experience. At the same time, reflective force feedback (which restricts users' movements), can, to date, be found primarily in mounted devices, such as the 'PHANToM' [7] and the 'Spidar' [5], and has recently proposed by Frischmann et al. as an inherent display for credit card swiping [4], and by Chu et al. for mouse wheels [2]. Striving to investigate further, we recently proposed reflective force actuation [14] for touch pens, most recently applied in musical expression [8].

PROTOTYPE

The proposed system (Fig. 1) consists of a pen-shaped casing, a steel ball on its tip, and an electromagnetic coil, which serves as a brake to the ball. The brake is controlled in correspondence to the GUI operations. All GUI components are represented schematically as white entities on white ground, solely discriminated from the background through their embossing: a deeper embossing resembles a greater weight of the component.

CONCEPT

We propose a number of concepts that show how GUIs could be haptically augmented in the future.

Prioritized Content

When exploring digital content, users may often find themselves in the face of large amounts of information. As a result, they may scan through the available information, focusing occasionally at comparatively unimportant items, but ignoring, rather in mistake, important items at the same time. A prototypical implementation we propose in this paper is an RSS reader (Fig. 1a), in which the items are ordered chronologically, but are the *stickier*, the *more important* they have been rated in the community.

Inherent Confirmation

Having developed a routine in operating computers is often advantageous. However, routine can also lead to unplanned consequences, when performing an operation without the appropriate thought. The prototype we present allows for consequence-laden operations, through dynamic restriction in their performance: When *deleting* a file, or signing a *contract*, the pen is *harder to move* (Fig. 1b) than while *copying* a file, or signing a *letter*.

Manual Dexterity

Productiveness and creativity often benefit from a well-designed user interface that disappears into the background. However, manual dexterity often depends on haptic feedback – something that GUIs often fail to provide. We propose a page layout application (Fig. 1c), in which rubberized grid lines can be placed on the canvas. Moving layout items over these will cause the friction to increase – allowing for more *fine-grained placement*.

CONCLUSION

We have explored frictional augmentation of GUIs, and the proposed designs indicate that such a form of actuation is of potential benefit for human-computer interaction. The dynamic change of a virtual object's physical friction can be a fruitful design space, providing users with additional information and enhancing the interaction with GUIs.

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