Combining Active and Passive Haptic Feedback for Rich Stylus Interactions

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Abstract

In this paper, we introduce the prototype of a low cost haptic augmented stylus for pen computing on touch screens. The stylus enriches the interaction through a dynamic passive and active haptic feedback. The passive feedback is generated by a brake system based on an electromagnetic coil. The additive active feedback is made by a vibrating motor. The pen provides a broad scale of different haptic feedback -- especially for the display of haptic surface cues and the assistance/support of stroking gestures.

1 Introduction

Touch screens are increasingly important for human-computer interaction. Through their versatile usability and the spatial overlap of output and input area, they offer a intuitive access to digital content. Despite the obvious advantages of this technology, there are limitations. Especially the missing haptic feedback of digital content, seems to inhibit the interaction process. According to Wigdor et. al (Widgor et al. 2009) and Brewster et. al (Brewster et al. 2007) a proper haptic feedback can improve interactions, regarding speed and accuracy. In previous study (Wintergerst et al. 2010) we introduced a simple and low cost stylus that enriches current stylus based touch screen interactions with a resistive (passive) feedback. It supports two-dimensional stroking gestures by increasing the lateral force that a user has to apply in order to move the stylus across a surface. However, this pen is limited to passive feedback, which constrains the haptic effect design. Therefore, we developed a new prototype with passive and active haptic feedback.

2 Stylus Prototype

The setup consists of a high precision steel ball, an electromagnetic coil, a vibrating motor and an aluminum housing (Fig. 1). The robust and low cost stylus (material-costs for the prototype are less than €60) is designed for touch screen interactions and similar to a conventional ball-pen. In contrast to approaches where the feedback actuators are integrated in the screen like Weiss et. al (Weiss et. al, 2010) the integration of the feedback actuators in the stylus allows the use of any kind of touch screen as well as the simultaneous use of multiple styli on one screen. The generation of haptic effects is based on the tracking position of the touch sensor on the particular touch screen. These positions are relayed via USB to the Personal Computer for further processing. After calculating the effect strength, the arduino board is assigned to control the electromagnetic coil and the vibrating motor (Fig. 2). The data handling of the current prototype is made by an arduino duemilanove developer board, based on an atmel atmega328p IC. The electromagnetic coil from IBS Magnet has a capacity of 1,4W (24V / 57mA) and an adhesive force up to 40N. The excentric vibrating motor has a capacity 0,1W (1,5V / 70mA).

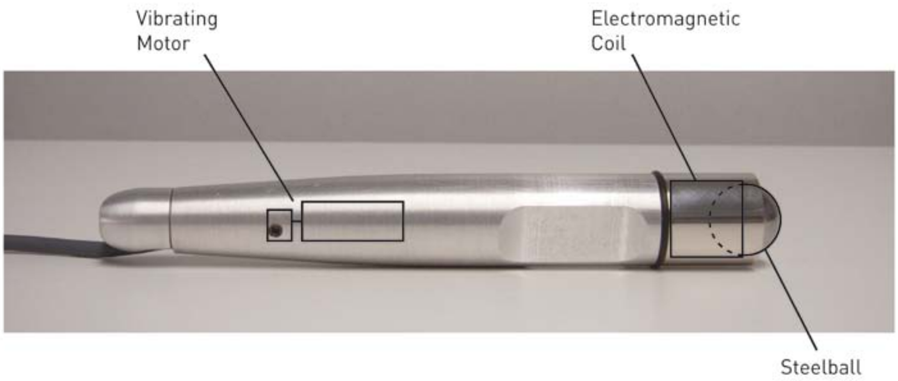

Figure 1: Setup of prototype with functional parts

3 Passive Feedback

Through a controlled electromagnetic flux, the friction between the steel ball and its guiding parts can be altered. This results in an increased friction between the stylus and the screen. Therefore, the user has to apply more force to move the stylus. To ensure that the friction between the steelball and the screen is high enough we applied a soft PVC film to the touch screen. This kind of passive feedback is especially suitable for displaying macro-textures like object edges, or continuous friction. However, due to the systems characteristics, the simulation of micro-textures like surface roughness is very limited. Within micro-textures, the coefficient of friction is reduced by the short periods of activity of the magnetic coil.

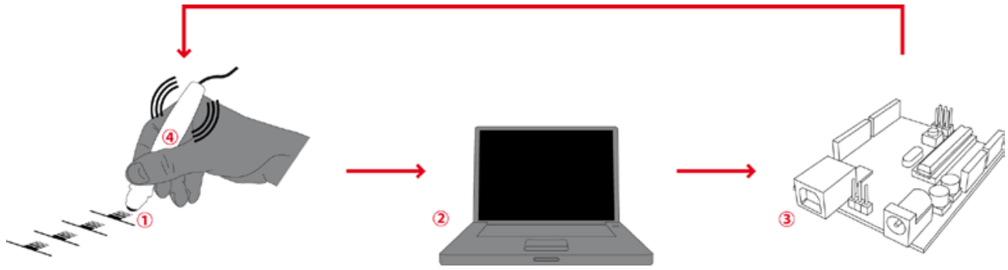

Figure 2: 1) Position tracking; 2) Processing of effect strength on the personal computer; 3) assignment of the arduino board to 4) control the actuators in the stylus.

4 Active Feedback

According to Lawrence et al.(Lawrence et al. 2007) vibrations play a prominent role in the perception of roughness of micro-textures. In addition, McMahan et al. and Romano et al. (McMahan et al. 2010, Romano et al. 2010) underline the role of high frequency vibration for texture perception. Therefore, we extended the stylus' functionality with a vibration feedback. First prototypes, operating solenoids which were aligned with the stylus' axis similar to the approach of Lee et. al (Lee et. al 2004), showed an interference of the solenoids' active feedback with the effects of the passive feedback - this caused an unintended modulation of passive frictional effects. We achieved good results with vibration motors as they are used in mobile phones. Through the combination of vibration and friction feedback, textures and surface structures can be displayed in a high resolution. The vibration motor further enables an active feedback as required in point and click interactions.

5 Interface Applications

In order to test various feedback combinations, we created multiple interface samples that depict common graphical user interface elements. Object edges, virtual object mass as well as guidelines can be displayed passively through a varying frictional strength and durability. Click confirmation of buttons and surface structures can be displayed via an active feedback of the vibration motor. A combination of the passive and the active feedback can be used to display the movement of an object on surfaces such as a folder that is dragged across the desktop (Fig.3). In this case the passive frictional feedback displays the objects virtual mass and the vibration feedback displays the vibration that the object causes by being dragged over the desktop surface.

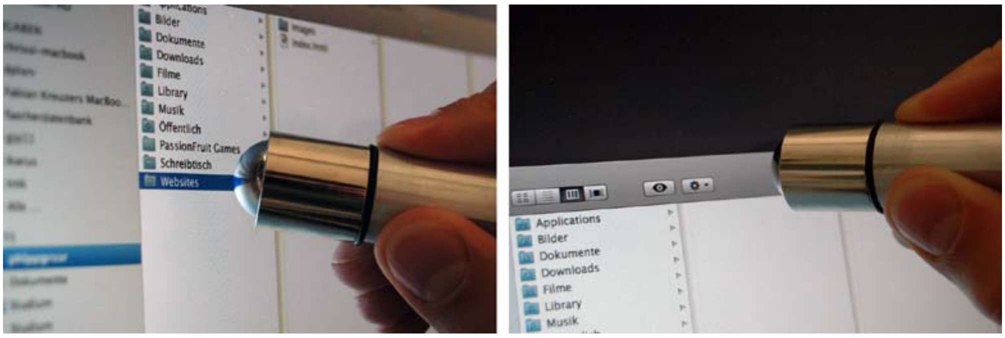

Figure 3: Passive frictional feedback for the augmentation of a highlighted selection (left) Combination of passive and active feedback, dragging a window (right).

6 Conclusion and Future Work

The introduced prototype convinces through its simple and robust setup. If considered individually both active and passive feedback are limited to the display of specific effect structures. Passive feedback can be used to display macro-textures, whereas vibration based active feedback is essential for communicating surface texture cues to the user. As a result, the combination of both, active and passive feedback offers a broad scale of options for the design of haptic object parameters. Future work will explore the full potential of this combination with respect to new interface solutions.

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