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Haptic Chameleon

G. Michelitsch, M. Osen, J. Williams, B. Jimenez, and S. Rapp

Sony Corporate Laboratories Europe
Hedelfinger Strasse 61
D-70327 Stuttgart, Germany
e-mail: {michelitsch, osen, williams, jimenez, rapp}@sony.de

Abstract. In this paper we will explain the concept of shape-changing user interface controls, which allow the user to physically grasp the meaning of a mode or function that he or she can apply to the system through such a control. We describe two prototype systems built for the purpose of demonstrating this new concept, and discuss related design issues.

1 Motivation and Concept

The haptic sense can reduce or even eliminate the need for the user to pay attention to a visual display on a device while using it. In addition, the use of computer controlled haptic feedback allows the rich feel of mechanical controls to be re-claimed, and combined with the dynamic nature of computer-oriented, graphical user interfaces. In this manner, haptically enhanced controls are able to take advantage of the best of both worlds, traditional consumer electronics and computers.

The Haptic Chameleon project aims to go one step further however, by developing a family of controls, which combine all the benefits of haptics technology with the ability to change shape and feel. This adds a new dimension to the ability of user interface controls by allowing users to physically grasp the meaning of explicit information such as mode.

Haptic Chameleon controls are real, physical objects, which are able to change both their shape, and material feel. The user holds the device and can squeeze different areas of it with different strengths much as one might do moulding a clay model. As a result, the control transforms itself into different shapes, which give an indication of the mode of operation to the user. At the same time, the force feedback associated with the operation of the control changes to match the new mode.

Previous work on shape-changing input-output devices has either concentrated on the physical resemblance between the device and an associated virtual object on the screen (see Murakami et al. [3]) without any haptic feedback, or the shape-changing aspect was simply realized by having multiple physical objects that the user would pick and choose from in order to attach it to a control unit for interacting with the system (see Snibbe, MacLean et al. [5]).

We expect the Haptic Chameleon concept to take the idea of tangible user interfaces (see Ishii et al. [1]) one step further by allowing the user to benefit from the intuitiveness of having distinct shapes for the user interface controls, yet be able to deal with a much smaller number of such controls in comparison with traditional approaches.

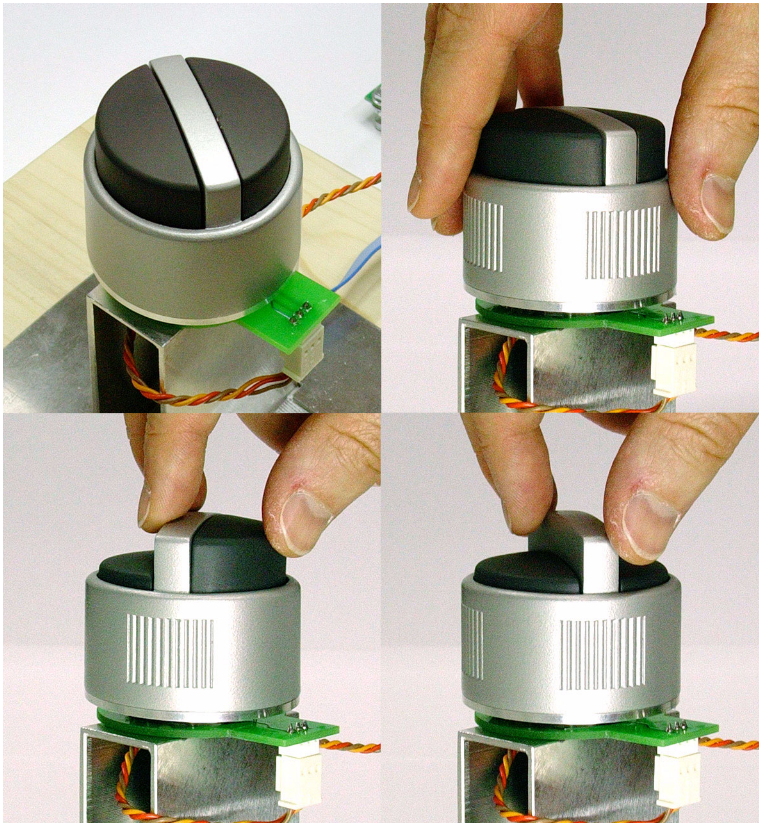

Fig. 1. Low fidelity prototype

2 Early Prototypes

In order to verify the anticipated benefits of this new concept, we followed a two-stage strategy of designing a low fidelity prototype as well as a high fidelity one, each focusing on different aspects of the concept.

The *low fidelity* prototype aims mainly to accurately reproduce the "grasp-ability" of the final device. The first prototype takes the form of a physical dial attached to a servomotor that allows for haptic effects, such as detents, viscosity effects, hard stops, etc. The dial incorporates buttons that the user can depress in order to alter the shape of the dial, which in turn results in different force-feedback profiles to be engaged (fig. 1).

The *high fidelity* prototype is simulated, and can be felt via a multi-Phantom setup. As a result we can virtually create any future haptic chameleon device and ensure that interaction is optimal long before the device is built (see also [2]). However, the user can only feel the device through thimbles attached to the Phantoms. The material sensation can therefore be well recreated, however the grasping action cannot (fig. 2).

We chose a novel way of controlling video content (compare with [5]) in order to demonstrate the new concept. The Haptic Chameleon takes the form of a dial that the user can rotate for navigation in video content. Depending on the chosen mode of control, the user can navigate either in a continuous manner (frame-by-frame), in a discrete manner (scene by scene), or in a semantic manner (e.g. jumping from one happy scene to the next one). The shapes for each mode were chosen to help the user remember its semantics. For the continuous mode we chose a circular shape, and the dial rotates smoothly with a deliberate amount of simulated viscosity applied (compare with [6]). The discrete mode is associated with a wedge-shaped variation of the control that also generates a distinct haptic detent when turned. For the semantic modes, the shape of the control was made to resemble either a smiley or a sad face.

3 Implementation Issues

In the low fidelity prototype we approximate the shape-changing feature of a Haptic Chameleon through the use of buttons that are kept in place by latches. Although this is a poor substitute for the anticipated experience of deforming an input device, it allows us to compare different shapes and their associated haptic feedback effects under realistic conditions in respect to the actual feel of grasping and turning such a device.

With the simulated Haptic Chameleon virtually built using the GHOST SDK by SensAble [4], we are able to convincingly create the sensation of deforming a Haptic Chameleon device, and feel the properties of different simulated materials at the same time. To that end, we experimented with various algorithms, one of which is described in more detail below.

Fig. 2. High fidelity prototype

We measure the reaction force of the PHANToM required to hold the surface of the virtual Haptic Chameleon in place, and compare it to a force threshold defined for each of the surface points that allow a shape-changing action. Once this threshold is overcome by pressure from the users finger, the following process starts. The system calculates a new shape for the Haptic Chameleon, which is slightly smaller than the previous one. With this new shape the reaction forces are measured again, and compared to the threshold defined for allowing shrinkage. This process is repeated until a shape close to the final shape for this transformation is reached, and the whole Haptic Chameleon then snaps into its new shape. The shrink factor used to calculate the new shape can be linear over time, which results in a sensation of squeezing a soft, non-elastic material such as polyurethane foam. Choosing different values for the shrink factor over time as the user presses onto the surface can be used to design various effects resembling the feel of shaping objects made from certain materials.

4 Conclusion

Through the exploration of alternative technologies for realizing the shape-changing feature we will ultimately be able to combine the aspects of both the low fidelity and the high fidelity demonstrator into a full-fledged Haptic Chameleon device.

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