Aesthetics of haptics : an experience approach to haptic interaction design

Citation for published version (APA):

Dassen, W. M., & Bruns, M. (2017). Aesthetics of haptics : an experience approach to haptic interaction design. In *Proceedings on the Conference on Designing Interactive Systems (DIS'17)*, 10-14 June 2017, Edinburgh, United Kingdom (pp. 254-258). Association for Computing Machinery, Inc.
<https://doi.org/10.1145/3064857.3079156>

DOI:

[10.1145/3064857.3079156](https://doi.org/10.1145/3064857.3079156)

Document status and date:

Published: 10/06/2017

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Aesthetics of Haptics: An Experience Approach to Haptic Interaction Design

Wendy Dassen

Industrial Design, TU Eindhoven
Eindhoven, The Netherlands
w.m.dassen@student.tue.nl

Miguel Bruns Alonso

Industrial Design, TU Eindhoven
Eindhoven, The Netherlands
mbruns@tue.nl

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the Owner/Author.
DIS'17 Companion, June 10-14, 2017, Edinburgh, United Kingdom
© 2017 Copyright is held by the owner/author(s).
ACM ISBN 978-1-4503-4991-8/17/06.
<http://dx.doi.org/10.1145/3064857.3079156>

Abstract

Technological developments are expanding the interaction possibilities for the haptic domain, allowing designers to program dynamic haptic feedback. While haptic sensations are emerging in design practice, the relation between programmable haptics and the user experience remains underexplored. This study presents a research-through-design approach on the design of a push button and a knob with multiple haptic sensations. Interaction design of these haptic sensations started from an experience perspective building on material qualities. We reflect on the design process and present future directions for research.

Author Keywords

Haptic interactions; aesthetics of interaction; user experience; push button; knob.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Haptics receive a growing interest in human computer interaction due to miniaturization and increased resolution of actuators, and the developments of robotic materials [e.g. 6,7]. Haptics address all aspects

Figure 1: A woolly blanket

Figure 2: Felt lantern

Figure 3: Rubber dome

of touch¹ and extend the possibilities of interactive systems beyond the extensively explored visual domain. Touch is the only sense that is reciprocal. Therefore, haptics has the potential to take full advantage of our perceptual-motor skills and fully enable embodied interaction with the digital domain.

In design practice, haptic interactions are emerging in for example the force feedback of Apple's notebook trackpad. Consequently, haptic interaction design (hIXD) is growing as a community and researchers have explored various ways to support designers in their process. For example, Moussette et al. [5] propose the concept of hands-on sketching haptic interactions. On the other hand, Hurtienne et al. [2] developed a haptic language using pictorial force representations with tangible counterparts. Also, toolkits are developed, e.g. for designing table top applications [3], or editing tools for vibro-tactile grid displays on screens, wearables or even furniture [9].

Although these examples support designers of haptic interactions, their explorations part from a functional and efficient perspective [3,9] or they address the hIXD process from a technological approach (e.g. generating clicks or force) [2,5]. Given the relevance of experience in interaction design (IXD), we want to investigate how one could start designing haptic interactions from an experience perspective. In this work-in-progress we describe the first iterations of what aesthetics of haptics might be. We describe a set of haptic interaction design prototypes, taking material experiences as our starting

point. We reflect on our design process in relation to theory-inspired design frameworks. Thereby we follow the research-through-design approach in the tradition of our Designing Quality in Interaction Group [11].

Aesthetics of (haptic) interactions

In IxD, there has always been a strong interest in supporting specific experiences when we engage with products [1]. This experience is influenced by the physical, sensual, cognitive, emotional, and aesthetic aspects of an interface. In IxD, the latter aspect has been extensively explored in what is called the aesthetics of interaction (AoI) [e.g. 4,8]. Lenz et al [4] consider that there are two aspects in the notion of AoI; the concrete interaction (the *how*) and the experience that derives from that interaction (the *why*). Furthermore, one of the central principles in the AoI is that it should respect all human skills (i.e. the cognitive, perceptual-motor, emotional and social) [8]. This includes the sense of touch, experienced most prominently through our hands. To address the full potential of haptics we present an alternative approach to hIXD not starting from a concrete development of haptics (the *how*), as emphasized in the projects mentioned above, but from an experience (the *why*).

Design of haptic effects

We started with the design of a push button, a widely-adopted mechanism in products that can have a variety of haptic sensations. This simple interaction was chosen, to emphasize the haptic qualities.

Experience

We initiated our experience driven approach by exploring material properties. Consider for example, a woolly blanket of which the soft haptic experience

¹ Perception of temperature and pain, perception of motion through sensory capabilities of muscles and joints and perception of contact or motion between skin and object.

Figure 4: Graphs drawn from the haptic effects. F is Force and P is position.

Figure 5: Push button (l) with control box (r).

provokes a feeling of warmth and coziness (Figure 1). Through a variety of material sketches we explored the abstraction of such an experience, which could consequently be translated into the design of the push button. Therefore, the sketches were restricted to small, push button-like interactions. In an abstract manner, Figure 2 and 3 show some examples of either matching or contrasting qualities that we could translate to our intended haptic interaction in the push button. For example, the felt lantern (Figure 2) has low resistance and was lightly resilient. We evaluated these qualities as accommodating and friendly, which matched our intended interaction. The rubber dome (Figure 3), has a relatively high resistance, a sudden resilience and felt a bit unpredictable. These qualities did not align with the haptic sensations of our intended soft and warm blanket experience.

Abstraction

The perceived haptic sensations (*how*) were drawn into small graphs (force to position) (Figure 4). For example, in the lantern the force slowly increases and decreases smoothly (Figure 4, #5). These graphs enabled us to program the effect in such a way that the values of force and position were easily adjustable.

Prototype

We developed a prototype consisting of an Arduino DUE microcontroller to program a 3-Phase Brushless Gimbal motor with a high torque (0.35 N/m) range. The position of the motor is measured with a non-contact rotary encoder (AS5145). An in-line slider crank was used to translate the rotational movement to a linear movement. Different effects can be activated and the force intensity of the effects can be changed through

the control box (Figure 5, r). The haptic feedback can be experienced through the push button (Figure 5, l).

Haptic effects

We designed six effects for the push button (Figure 4):

- *Constant force* (#1): the counterforce of the button is constant along the entire downward movement.
- *Assisting force* (#2): the button renders a force along with the downward motion when pressed, creating a 'falling motion'.
- *Single click* (#3): a high force barrier is placed at the end of the downward motion, mimicking a click.
- *Two clicks* (#4): both half way the motion and at the end a barrier is programmed.
- *Gradual force* (#5): the intensity of the counter force increases until half way the downward motion and then decreases again.
- *Resilience* (#6): the counter force increases along the downward motion. Inherent to this effect, the button will come up again; as if there is a spring underneath the button.

Various graduate students working on haptics gave feedback on the haptic sensations. From these discussions, effect #6 (*resilience*) appeared most engaging because there was no end to the interaction (the button returned to its original position whereas in the other effects it did not). Therefore, we continued to explore haptic sensations in a knob, which has no set beginning or end. The technological setup equals the button, but without mechanical translation. Six effects with variables were designed (Figure 6) for the knob:

- *Intensity of barriers* (#7): the amount of force needed to rotate over a barrier as variable.

Figure 6: Visual illustrations of the haptic effects of the knob.

- *Distance between barriers (#8)*: the number of barriers per rotation as variable.
- *Resilience (#9)*: the counter force that increases along the rotation as variable. When the button is released, it will rotate back to its starting position.
- *Random barrier (#10)*: The position of the barrier with a variable random change once rotated over.
- *Barrier with impact (#11)*: when rotated against a barrier, the knob slightly rotates back and the barrier shifts forward in a variable distance.
- *Responsive force (#12)*: The variable intensity of the counterforce is dependent on the speed of the user. The faster it rotates, the higher the intensity.

Discussion and future work

Haptic effects in interactive products are mostly designed from a technology driven (or concrete) perspective. Here, we present an alternative approach to hIXD, by starting our explorative design approach from an experience perspective (*the why*) and translating material properties into haptic qualities that contribute to evoking an experience (*the how*). Through an experience approach we first abstracted perceived haptic material qualities to design haptic effects using a dedicated prototype. The material sketches were used to relate experiences to perceived haptic interactions.

While previous studies [2,5] focused on designing specific haptic sensations, our work-in-progress illustrates that haptic sensations can have a lot more depth and subtleness. Haptic sensations will need to be designed to support aesthetic experiences and specific tools [e.g. 3,9] could support this process. We will further analyze how designers can start sketching a haptic sensation from an intended experience (e.g. how can we design a button that feels like a foam or what

does it mean to inverse the properties of a foam?). Material sketches can enable designers to explore the aesthetics of haptics like sketches or form studies.

Although we focused purely on the haptic sense, it is mostly pre-informed by other modalities such as visual perception of physical properties (e.g. when picking up a plastic cup one applies less force than with a ceramic mug). On a more abstract level, this phenomenon is also addressed as one of the main principles of the AoI, which considers that besides the whole human body, the (social) context, practical use and dynamic form of design play a role too [8]. Thus, it seems impossible to think of aesthetics as an inherent quality of haptics, as experiences emerge in context and in use. Therefore, we will connect dynamic haptic qualities to other modalities (e.g. graphical user interfaces) and apply them in a (product) context to deepen our understanding of programmable haptics.

As part of the AoI, Wensveen et al. [10] explored how digital devices can inform users by coupling action and function through augmented information regarding time, location, direction, modality, dynamics and expression; like mechanical products do with inherent information. Given that haptic interfaces have programmable inherent qualities, further research should explore its effect on feedback and feedforward when merging the digital and physical domain. Particularly, how aesthetic haptics can invite or afford certain interactions? Finally, the resolution of haptic technologies is still rather limited compared to visual displays. However, we believe that an experience driven approach can provide directions to further develop smart actuators and robotic materials enabling high-resolution haptic interactions and experiences.

References

1. Forlizzi, J. and Battarbee, K. 2004. Understanding experience in interactive systems. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques* (DIS '04). ACM, New York, NY, USA, 261-268. DOI=<http://dx.doi.org/10.1145/1013115.1013152>
2. Hurtienne, J., Löffler, D., Gadegast, P. and Steffi Hußlein. 2015. Comparing Pictorial and Tangible Notations of Force Image Schemas. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction* (TEI '15). ACM, New York, NY, USA, 249-256. DOI=<http://dx.doi.org/10.1145/2677199.2680553>
3. Ledo, D., Nacenta, M.A., Marquardt, N., Boring, S., and Saul Greenberg, S. 2012. The HapticTouch toolkit: enabling exploration of haptic interactions. In *Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction* (TEI '12), Stephen N. Spencer (Ed.). ACM, New York, NY, USA, 115-122. DOI=<http://dx.doi.org/10.1145/2148131.2148157>
4. Lenz, E., Diefenbach, S. and Hassenzahl, H. 2014. Aesthetics of interaction: a literature synthesis. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational* (NordiCHI '14). ACM, New York, NY, USA, 628-637. DOI=<http://dx.doi.org/10.1145/2639189.2639198>
5. Moussette, C. and Richard Banks, R. 2011. Designing through making: exploring the simple haptic design space. In *Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction* (TEI '11). ACM, New York, NY, USA, 279-282. DOI=<http://dx.doi.org/10.1145/1935701.193576>
6. Nakagaki, K., Vink, L., Counts, J., Windham, D., Leithinger, D., Follmer, S. and Ishii, H. 2016. Materialable: Rendering Dynamic Material Properties in Response to Direct Physical Touch with Shape Changing Interfaces. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). ACM, New York, NY, USA, 2764-2772. DOI=<https://doi.org/10.1145/2858036.2858104>
7. Ou, J., Dublon, G., Cheng, C.Y., Heibeck, F., Willis, K. and Ishii, H. 2016. Cillia: 3D Printed Micro-Pillar Structures for Surface Texture, Actuation and Sensing. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). ACM, New York, NY, USA, 5753-5764. DOI=<https://doi.org/10.1145/2858036.2858257>
8. Ross, P. R. and Wensveen, S. A. G. (2010). Designing aesthetics of behavior in interaction: Using aesthetic experience as a mechanism for design. *International Journal of Design*, 4(2), 3-13.
9. Schneider, O.S., Israr, A. and MacLean, K.E. 2015. Tactile Animation by Direct Manipulation of Grid Displays. In *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology* (UIST '15). ACM, New York, NY, USA, 21-30. DOI=<https://doi.org/10.1145/2807442.2807470>
10. Wensveen, S. A. G., Djajadiningrat, J. P. and Overbeeke, C. J. 2004. Interaction frogger: a design framework to couple action and function through feedback and feedforward. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques* (DIS '04). ACM, New York, NY, USA, 177-184. DOI=<http://dx.doi.org/10.1145/1013115.1013140>
11. John Zimmerman, Erik Stolterman, and Jodi Forlizzi. 2010. An analysis and critique of *Research through Design*: towards a formalization of a research approach. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems* (DIS '10). ACM, New York, NY, USA, 310-319. DOI=10.1145/1858171.1858228 <http://doi.acm.org/10.1145/1858171.1858228>