Designing for Haptic and Embodied Interaction with Feelix

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ABSTRACT

Force feedback and shape change provide unique interaction qualities that can be favourable for the design of more intelligent physical user interfaces, as communication revolves to a large extent around body language and gestures. Currently, there is a dearth of design tools which are needed to accelerate exploration of the design space of haptic and shape change in user interfaces, given the challenges associated with the haptic modality and the expertise that is required for the development of such interfaces. Design tools have the potential to improve the accessibility of these modalities as design material within HCI and facilitate exploration of the design space. In this studio, we will use the design tool Feelix to explore possibilities and opportunities for force feedback and shape change in actuated interfaces.

CCS CONCEPTS

• **Applied computing** → Physical sciences and engineering; Engineering; Computer-aided design; • **Hardware** → Communication hardware, interfaces and storage; Tactile and hand-based interfaces; Haptic devices.

KEYWORDS

Haptic interaction design, Shape Changing Interfaces, Force feedback, Tools and toolkits, Embodied interaction

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1 INTRODUCTION

Non-verbal interaction plays an important role in human communication. Many of the cues that are conveyed through body language happen unconsciously, but body language can also be used deliberately to assist in shaping, expressing, and sharing thoughts in interactions with others. Being able to convey information in this manner can contribute to the quality of interaction with intelligent physical interfaces. Shape changing interfaces are well known for their expressive qualities [1]. In addition, they exhibit bi-directional qualities that allow for interaction mediated through force feedback which can be employed to mediate control or communicate information. Together, these modalities provide unique interaction qualities that can complement interactions with (intelligent) physical user interfaces.

In this studio, we will focus on interaction design using Feelix [12, 13], a design tool that empowers designers to explore with the design of force feedback and motion in user interfaces. The tool enables designers to control plug-and-play hardware modules that can be integrated in a wide variety of systems. There exist various examples of designs that explore the value of force feedback and shape change for interaction design that make use of the same technology as Feelix. The examples include the haptic pedal [15], an interface for an intelligent thermostat [11], and the shape changing robotic interface FRANK. The haptic accelerator pedal (Figure 1a) assists users in eco-driving behaviour using force feedback. The thermostat interface (Figure 1b) employs force feedback to mediate control in a human-system dialog. The behaviour of the knob ranges from submissive to dominant and is conveyed through the size of the knob in combination with subtle, assistive, or strong directional force feedback. The shape changing material FRANK (Figure 1c) is a surface with rubber-like hairy elements that uses its dynamic temporal form to express behaviour that changes in response to human touch [2]. These examples illustrate different ways in which force feedback and shape change can be employed in human-system interaction. The development of such interfaces requires expertise in different areas. In this studio, we use Feelix [12, 13] which was developed to make designing with force feedback and shape change more accessible. We will focus on designing feedback for systems that afford diverse interaction possibilities for expressive user input and provide expressive feedback conveyed in physical interaction and through dynamic motion.

2 THEORETICAL GROUNDING

Research on haptics and shape change can be accelerated with toolkits that empower designers to explore the design space, as tools and toolkits have the capacity to capture and simplify expertise [8]. Designers have access to an abundance of editing tools for visual and audio design, while haptic interaction design is still at an early stage of development [16]. Research in the area of force feedback has contributed exploration techniques such as physical sketching [10], and a variety of low-cost DIY haptic devices often developed for education and haptic exploration (e.g. [4, 5, 14]). Despite technological advances and an increased interest in haptics in recent years, there remains a dearth of tools that empower designers to explore with force feedback and shape change. In 2003, Enriquez and MacLean presented the Hapticon Editor [3], followed by the Haptic Icon Prototyper a few years later [17]. Since then, a handful of commercial tools have been introduced that support the design of force feedback mostly for haptic spatial devices (e.g. [19]). These examples focus on the control of haptic devices. In order to explore

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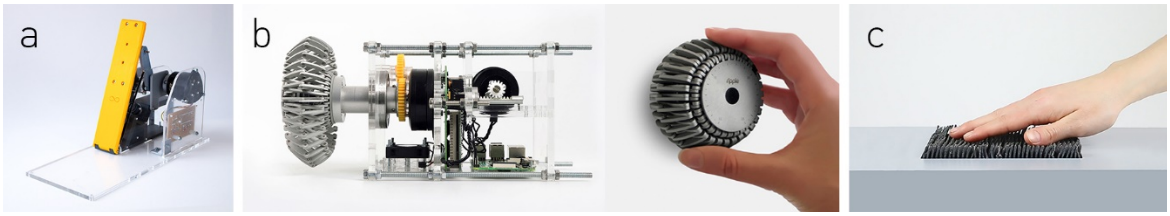

Figure 1: a) Haptic accelerator pedal by De Ruiter et al. [15], b) ripple thermostat by Van Oosterhout et al. [11], and c) the shape changing interface FRANK by Nogueira Amorim, Caleca, Loos and De Ruiter [2].

these modalities in a broader context of customizable haptic and shape changing interfaces, more design tools are needed that alleviate some of the technical difficulties and accelerate exploration of the design space, considering the challenges and the required expertise associated with the design and control haptic and shape changing interfaces.

The design of force feedback is closely intertwined with shape change. Shape changing interfaces use their physical shape to convey information, meaning, and affect [1]. The dynamic characteristics and nuances in motion can for instance be used to convey information about the behaviour or inner state of a system. In addition, these interfaces can use their physical shape as a means of input as well as output. These bidirectional qualities allow for shared or negotiated control. Designing for kinematic motion is supported by a wide variety of tools in contrast to the design of force feedback. Examples include tools for media (e.g. [7, 18]), robotics (e.g. [6, 9]), and the like. However, to our knowledge there exist no tools oriented towards force feedback and motion design for shape changing interfaces.

In this studio, we will make use of Feelix [13], a tool that has been developed to support the interaction design process of force feedback and motion in actuated interfaces. The tool provides freedom for designers to implement force feedback and shape change in custom prototypes through an exploratory and iterative design process.

3 STUDIO PROPOSAL

During the studio participants will be introduced to designing force feedback and motion with Feelix. Participants will experiment with combining different hardware modules to create models that afford expressive interactions. These models will be used to explore opportunities for machine learning to identify patterns in interactions with the kinematic models. Through this process, participants will be able to experiment with possibilities for haptic and embodied interaction for shape changing interfaces. The studio will conclude with a reflective discussion through which we aim to collect insights into the design process and experience that could inform the research agenda on haptic interaction design and shape change. The insights will also contribute to the development of Feelix and could inform the design of other design tools. We plan to compile the findings in a publication.

4 STUDIO LEARNING GOALS

During the studio, participants will engage in an iterative design process. In three iterations, participants learn the basics of force feedback and motion design with Feelix. We will also explore with designing for expressive interaction through the development of kinematic models that allow for diverse interaction possibilities for expressive input, and nuances in shape or dynamic motion to convey expressive feedback. The exploration process will conclude with the development of machine learning (ML) models to identify patterns in interaction and haptic exploratory procedures. The studio has three learning goals:

(1) *Experiment with the design of force feedback and motion in kinematic interfaces using Feelix.* In this studio, participants will learn how to design force feedback and motion with Feelix through an explorative design process.
(2) *Experiment with designing for expressive input and output in multi-actuator systems.* New interaction possibilities will be created by combining multiple hardware modules into larger kinematic systems. Participants will form groups to create kinematic models. They will have the opportunity to combine hardware modules in different ways and to explore with the design of force feedback in motion for different kinematic models.
(3) *Experiment with the development of ML models to identify patterns in interaction such as interaction techniques or emotions.* Kinematic models that afford diverse interaction possibilities provide opportunities for expressive user input and identification of interaction patterns in the collected input. Groups will use the kinematic models that they developed to experiment with ML models to identify interaction patterns.

5 MATERIALS TO BE EXPLORED

Feelix [13] is a design tool that was developed to make the design of force feedback and shape change more accessible for designers. The tool consists of a software application, a C++ library, and hardware modules. The hardware can be directly controlled with the application, whereas the C++ library can be used to import effects designed in Feelix using code to support integration with external components. Attendees need to bring their own laptop and a computer mouse is recommended, hardware modules will be provided during the tutorial. The hardware is connected to the laptop via USB. To prepare for the studio, attendees are encouraged to watch the introduction video on the studio website: https://studio.feelix.xyz.

The software application (Figure 2, left) provides a canvas to sketch haptic and motion effects using various graphical notations. Designers can choose a graphical notation that best fits the nature of the designed effect or aligns with their personal preference. The effects can be combined in collections. From here, the effects can

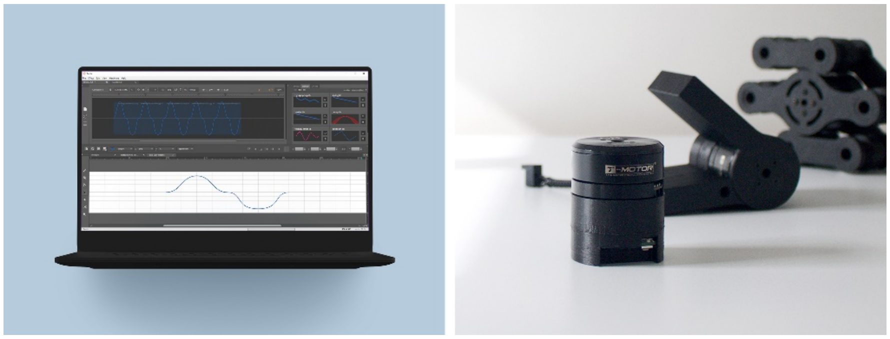

Figure 2: Feelix application and hardware module.

be uploaded to the motor, after which they can be tweaked and refined. When designers are satisfied with the designed effect, it can be exported as code. Feelix also provides methods to explore with identifying patterns in user input, as shape changing interfaces can be designed to provide diverse interaction affordances, allowing for freedom of expression in user input. We embedded functionality to develop ML models using TensorFlowJS. A model is trained on data gathered from physical interactions with a kinematic model. The collected data is then labelled and used to train the model. After training the model, it can be deployed to classify physical interactions. The functionality is currently limited to classification using neural networks and supervised learning.

The hardware modules (Figure 2, right) consist of a high torque brushless dc motor, driven by a three-phase motor driver. The position is monitored with a magnetic encoder. A custom STM32F401 microcontroller is used to control the motor and communicate with the software application.

6 STUDIO SCHEDULE

The schedule of the studio will be as follows:

Welcome (30 minutes)

Introduction to the studio and to designing with Feelix

Design iteration 1 (1 hour)

To get acquainted with Feelix, participants each receive one hardware module to get started with designing feedback using Feelix. In case enough hardware modules are available, otherwise groups will be formed.

Design iteration 2 (2 hours)

Participants form groups and combine their hardware modules to create kinematic designs with more degrees of freedom and continue their explorations with feedback design as a group.

Design iteration 3 (2 hours)

In groups, participants will develop and train ML models for their kinematic design.

Reflective Discussion (30 minutes)

All participants engage in a reflective discussion on explored methods and techniques. Participants can exchange experiences, best practices, ideas, and make contacts for potential collaborations.

7 HYBRID CONFERENCE

The studio is designed to take place on-site. However, in case of a virtual conference, the plans for the studio will change as follows: materials will be sent to participants before onset of the studio. When required, different sessions can be created for people from different time zones. In a virtual setting, group work will be replaced with individual design and exploration exercises. The focus will also shift to designing for force feedback and shape change in one degree-of-freedom systems using various models to extend interaction possibilities. In a hybrid setting, participants can join groups at the on-site conference remotely. People who participate remotely in an on-site group can design feedback together with other group members using an online repository to share designs.

8 SUPPORTING DOCUMENTS AND RESOURCES

The software application and documentation can be found on https://feelix.xyz. Hardware modules will be provided during the studio, and an online repository will be created to share documents such as design files, videos, and photographs.

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