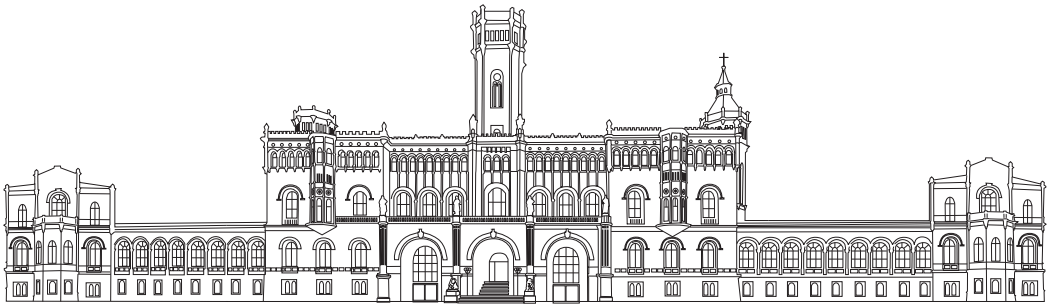

LEIBNIZ UNIVERSITÄT HANNOVER

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CASUAL INTERACTION WITH A BRACELET

A Thesis presented for the degree of Master of Science

by

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ABSTRACT

Short summary of the contents in English...

ZUSAMMENFASSUNG

Kurze Zusammenfassung des Inhaltes in deutscher Sprache...

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ACRONYMS

STL	Sterolithography
HCI	Human-Computer Interaction
IR	Infrared
LED	Light Emitting Diode
SPP	Serial Port Profile

1 INTRODUCTION

2 USAGE SCENARIO

> Alice comes home from grocery shopping. While carrying her stuff to the kitchen, she quickly turns on the light using a simple hand gesture.
>
> After storing everything, she decides to relax in the living room by reading a book. After turning the kitchen lights off with a gesture, she makes herself comfortable on the sofa and picks up the book. To feel more comfortable, Alice dims the living room light a little by touching the bracelet rim and sliding towards her body. The living room lights dim accordingly, so she doesn't need to look any closer at the bracelet.
>
> Later that day, Alice prepares the dinner. While the food is finally in the oven, Alice returns to the living room and prepares the table for dining with her friends that will show up later. She uses the the bracelet's e-paper display and touch controls to specify exact colors and brightnesses for each light source in the room. Alice saves three lighting setups together with unique activation gestures: A colorful setting for their guests' arrival and enjoying the welcoming drinks, a well-matched dining setup with focus on the table and foods, and a darker, lounge-like mood for the after-dinner party. Changing between these presets with hand gestures allows Alice to focus on her guests and on the meal instead of wasting time and focus by fiddling with wall panels or switches.

This scenario illustrates three different levels of casual interaction with a device: Eyes-free gestures without touching the bracelet, touch and slide interaction with optional eye contact, and focused fine-tuning of different settings with touch input and visual feedback on a display.

The mentioned interactions induce several requirements for the device. First, the device should stay where it is needed without encumbering the user. Typical remotes or smartphones occupy at least one hand for every interaction they offer. This is not desired, so traditional hand-held devices do not fit the scenario presented above. Instead, there is the need for a wearable device that is attached to the body without getting in the way during everyday activities.

Second, touch-free interaction (i.e. control by gestures) should be possible with respect to the first level of casual interaction pictured above. Capacitive touch input offers flexibility and versatility com-

pared to traditional keypads and enables gestured touch input. The display should be big enough to visualize complex information in order to fulfill the task of focused interaction, while at the same time a long battery life is required of the device.

A bracelet-typed device can fulfill all the requirements stated above. It is slim and doesn't encumber you, so it can be worn on the arm all day.

3 RELATED WORK

4 THE BRACELET

The interactive bracelet consists mainly of an electronic ink display and several touch sensors for conscious interaction and a motion sensor for gesture recognition. The bracelet's design focuses on wearing comfort, low weight and small error of unintended activation.

4.1 MANUFACTURING TECHNIQUES

In this section, the various methods and tools used for designing and manufacturing the bracelet prototypes will be explained in detail.

4.1.1 *Computer Aided Design*

The finished designs are then exported as meshes (usually in Sterolithography (STL) format) for printing.

4.1.2 *3D Printing*

The Human-Computer Interaction (HCI) group's workshop includes a plaster-based 3D printer, a ProJet 360 by 3DSystems, Inc. The print bed is filled with Visijet PXL material, a plaster-like powder. The model is then created by printing the binder fluid with an inkjet printhead onto the plaster. After each printed layer, a new thin layer of plaster is added to the print. This allows even delicate structures without any additional supports, since the printed object is surrounded by plaster powder. The finished object is then carefully removed from the build bed and any excess powder is gently brushed or blown off. Without further hardening, the objects are very fragile and easy to break, even with the pressurized air pistol included in the printer. In order to drastically increase the strength of the prints, they are infiltrated with a fluid. This step adds strength and hardens the material, resulting in a sturdy printed object. However, the objects created with this technique are very rigid and any bending load might break them easily. Wall strengths of 1.5 mm and up have been proven sturdy enough for a bracelet shape, although this also depends on the bracelet's shape.

4.1.3 *Silicone Casting*

Another manufacturing process for bracelet prototypes used in this thesis is liquid silicone casting. A mold is printed and then filled with a two compound mix.

4.2 DESIGN PROCESS AND PROTOTYPE MANUFACTURING

The design process for the interactive bracelet presented in this thesis went through different stages. At first, a 3D-printed casing was favored, but later on a cast silicone bracelet turned out to be very comfortable for the user. The different prototypes are explained in detail in the following sections.

4.2.1 *Constant Thickness*

This very simple first approach is basically a rectangular profile rotated around a curve. It has the same magnitude at any point, which makes it quite uncomfortable to wear, especially under a layer of clothing.

4.2.2 *Tapered Shape*

With a tapered shape and non-uniform thickness, the bracelet looks more appealing. The reduced wall strength (0.7mm) made it very fragile in fabrication, two (out of two) prints broke during post-processing. Wearing the cuff while working on a PC feels only slightly uncomfortable, but twisting the hand is encumbered by the tight-fitting bracelet. Future prototypes should allow more space between the arm and the bracelet to ensure better comfort.

4.2.3 *Tapered Shape with Lid*

A modified design of Prototype 2 features a removable lid. The structure of the lid turned out to be too fine, especially the flexible part was too thin to work as intended. The size of the bracelet was increased a little to render it more comfortable to wear. Still, the rigid shape leads to clumsiness.

4.2.4 *Amico Bracelet Print-out*

A print of the tri-part design by Daniel Muschke on GrabCAD turned out to be a little too small, but the style felt more comfortable than the previous prototypes.

4.2.5 *Modified Tri-Part Design*

A re-work of Prototype 3 involves hinge research. The first draft turned out way too small, the second iteration was too big. Further research into this shape was paused because a long, bracelet-like display was considered instead of a small one.

4.2.6 *Silicone Bracelet*

After some consideration on a flexible, bracelet-shaped e-ink display, a prototype of silicone was considered. Mold design turned out a little tricky but finally succeeded. I printed a two-piece mold which only needed a little post-processing to fit properly together. The mold was coated with black spray paint to make the inside a little smoother, but this didn't work as intended so the paining step can be omitted in future mold making processes. The filling holes for the silicone were too small, and the silicone was more viscous than expected.

The first cast with a closed mold and filling through the holes was unsuccessful; it produced two small end pieces and nothing in between. For following casts, one part of the mold was filled with silicone and closed afterwards; this turned out significantly better. The orientation the mold is placed during dry period is also relevenat, as air bubbles will float towards the "top" of the mold, leading to instabilities. Getting the silicone part out of the mold was no problem.

The bracelet design involved a magnet clasp, but it was infeasible to strongly attach magnets to silicone with anything but silicone itself and they will likely jump out of place and snap together if placed closely in the design.

Two casts were made, one with each of the available silicone mixtures. The softer one was slightly too soft and had a disappealing color. As of yet, no tests have been conducted regarding the tightness of the display inside the bracelet.

4.2.7 *One-Piece Silicone Bracelet*

The next step was to cast a ring-like bracelet in one piece, so the issue with the clasp was no concern. The mold for this prototype consists of three pieces, two rings and a bottom plate. Unfortunately, the molds could not be recovered after the cast and had to be destroyed. In order to prevent unnecessary waste of material, the wall strength was reduced to 2.5 mm which turned out to be strong enough to survive the cast. However, one-time molds allow for tunnels in the display area.

This mold was much harder to fill with silicone than the previous one. Especially the Sortaclear silicone was too viscous to fill the com-

plete mold, resulting in broken casts. The green Mold Star silicone turned out to work quite well.

5 INTERACTIVE LIGHT SOURCE

The previously mentioned light source for the scenario is built around a 12V powered RGB Light Emitting Diode (LED) strip with approximately XX LEDs. The original controller box which included an Infrared (IR) receiver for a remote was taken off and replaced by an Arduino Uno with a custom shield featuring a Roving Networks RN42 Bluetooth module. The whole setup is powered by a standard 12V an Arduino-controlled LED strip. Communication with the bracelet will take place via Bluetooth. The RN42 module implements the Bluetooth Serial Port Profile (SPP) and can be accessed easily with the `SoftwareSerial` module from the Arduino standard library. For a color change, the RGB color code is transmitted in a 9-digit string composed of three values from 000 to 255. Note that all values must have three digits, leading zeros must not be omitted. Those color values are transmitted directly to the red, green, and blue channels of the LED strip, a simple fading algorithm prevents disruptive flashing when switching colors.

6 INTERACTION

6.1 PAIRING THE BRACELET WITH A LIGHT SOURCE

6.2 GESTURE RECOGNITION

6.3 CASUAL TOUCH INPUT

6.4 PRECISE TOUCH INPUT

6.5 PRESETS AND CONFIGURATION

7 EVALUATION

7.1 STUDY DESIGN

7.2 RESULTS

7.3 DISCUSSION

8 CONCLUSION AND FUTURE WORK

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Hannover, December 2014

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