Lo-fi prototyping a refreshable pin display

Charlotte Magnusson[1] , Taqwa Saeed[1] and Kirsten Rassmus-Gröhn[1]

[1] Department of Design Sciences, Lund University, Sweden
charlotte.magnusson@design.lth.se
taqwa.saeed@design.lth.se
kirsten.rassmus-grohn@design.lth.se

Abstract. This paper presents a way of creating and working with lo-fi materials for a tactile refreshable pin display. We briefly describe the design process leading up to a working design and report on qualitative results from a pilot test with three blind braille readers. The materials were seen to work well, and supported co-design discussions around the future design of, and interaction with, the – as yet, non-existing – tactile device.

Keywords: Tactile display, lo-fi, co-design.

1 Introduction

Prototyping haptics early in the design process is generally a challenge. It is often hard to make simple prototypes, the way one usually does for graphic interfaces. That is not to say it is impossible, in [4] several examples are provided of how one can work with early prototypes and co-design when designing haptic systems. In the ABILITY project, the goal is to design and develop a novel, refreshable, tactile pin display. The initial interviews in the project showed that it was difficult for the end users to envision what it would really be like to interact with such a display. A well-established approach when working with co-design is to make use of lo-fi materials. Using lo-fi, instead of exiting devices, allows both users and design team to focus on concepts and functionality, and potentially facilitates thinking "out of the box" [7]. Thus we decided to embark on a series of lo-fi workshops aimed at allowing us to better discuss our future designs with our potential end users. It turned out to be less straight forward than we had initially hoped, and in this paper, we describe the design process for creating the lo-fi materials. In addition, we report on results obtained from a pilot co-design workshop that was carried out using the developed materials. Since larger, affordable, refreshable pin displays would be an important accessibility device, and this is a field where there is currently on going developments (e.g., [11], [12]), it is our hope the presented lo-fi workshop design will be useful for anyone working with this type of system.

2 Participatory design and co-design

Participatory design and co-design is a subset of human centred design where the design is done with the users, rather than for the users. An often cited early participatory design project was UTOPIA [1], which in the early 80's set out to design a graphic workstation for a newspaper together with the newspaper graphic workers. The participatory design toolbox has been extended since UTOPIA, but central to this approach is low-fidelity (lo-fi) prototyping and design sessions or workshops together with the intended users of the future technology. While participatory design has strong political roots, and was originally developed for design within a workplace environment, co-design can be used as a more general term for design activities involving future users as co-designers [8].

A common type of design activity in co-design is the design workshop. Workshops are hands-on sessions where small groups of persons (end users, professionals, etc.) work creatively together. The key is the group work, allowing for a creative interaction between group members that involves elements of brainstorming (expressed ideas lead to new ideas). At a workshop one can work with concepts, technologies and practical examples. Co-design workshops are a well-established tool, and although many of the commonly used workshop tools such as post-it notes, visual sketches, etc. are visual, there is nothing per se, that prevents the involvement of persons with visual impairments in co-creative design activities, as long as activities and materials are designed appropriately [4].

3 Tactile interactive graphics

There have been several devices designed specifically to present tactile information. The OPTACON (using electromechanical vibrations) was launched in 1971 (stopped being manufactured in 1996) and the VTPlayer from VirTouch, a mouse with two braille cells on top (no longer commercially available) are two examples. More elaborate tactile displays use larger numbers of moveable pins to present tactile patterns. An obvious example of this type of display is the commonly used refreshable braille display. On this type of display, the distances between the pins are tailored to braille, and are thus not equidistant. To present graphs, maps or images, the pins on the display need to be larger and equidistantly spread over the surface. An example of this type of display is the HyperBraille (https://metec-ag.de/en/produkte-graphik-display.php), used in [9] to convey map information. Other tactile displays are Orbit's Graphiti (Graphiti Reseach) and Dot Pad (Dot Pad Inc. 2022) [11], [12]. The Graphiti technology has been used to convey motion as the pin display shows consecutive graphics depicting the chronological order of images of a body in motion [2], and can also track the finger of the user. The Dot Pad, on the other hand, is output only (on the pin display). Most of these devices, are difficult to use on the go, due to their weight and size, or the need to connect to other devices. As electromechanical systems, these systems are often quite noisy, the cost of purchase for existing devices is still high, and this is an area with ongoing research and development. Some of this is done in the EU project ABILITY.

4 Lo-fi prototype materials for a refreshable pin-display

Our first idea for creating lo-fi material was to use 3D prints and laser cuts. These were first done to investigate how Braille would turn out on a display with equidistant pin spacings. We also 3D-printed pin renderings of images as an initial attempt to generate materials for the workshops, Fig 1. While 3D prints would make durable prototypes that could be used multiple times, it turned out to be very time consuming to create them, since the tasks we were planning for our workshop contained several versions of maps and images.. Furthermore, it turned out to be a challenge to get the feel of the pins right. The pins became a little sharp, and unpleasantly rough. Printing the plates standing or tilted in an FDM printer (where plastic filament is heated) helped making the pins smoother, but this was difficult to do with larger images.

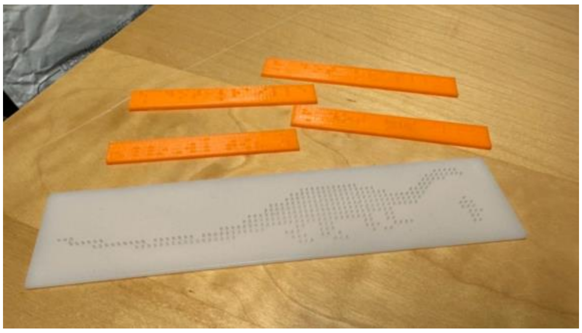

Fig. 1. Early experiments with 3D-printed Braille spacing (FDM printer) and dot rendering of a dinosaur and a person (SLS printer, selective laser sintering of nylon powder).

Another technique we investigated, was to use a Braille embosser from Index Braille, https://www.indexbraille.com/. However, modern Braille embossers make floating point prints which means that the dots cannot be placed at equidistant spacings, which thus would not mimic the dot spacings of the planned tactile display.

After this, we explored the possibility of gluing small metal balls to a laser cut template with equidistant holes where the pins should be. While this generated pins that felt good and were very realistic to the touch compared to the existing early technical prototype, it was extremely time consuming to glue all the balls.

Finally, an experiment with a tool for hand punching Braille characters on paper showed the way forward. With this technique, it was possible to create outlines, and the pins/dots also felt quite reasonable to the touch. To get the same spacings of the pins/dots as the future pin display would have, an acrylic plastic board template, with the planned number and spacing of pins for the envisioned pin display was created with a laser cutter (Fig 2, left). This way of generating images would additionally potentially allow users to add elements the images during the workshop (this possibility was not used in the current set of workshops but could be used in future activities).

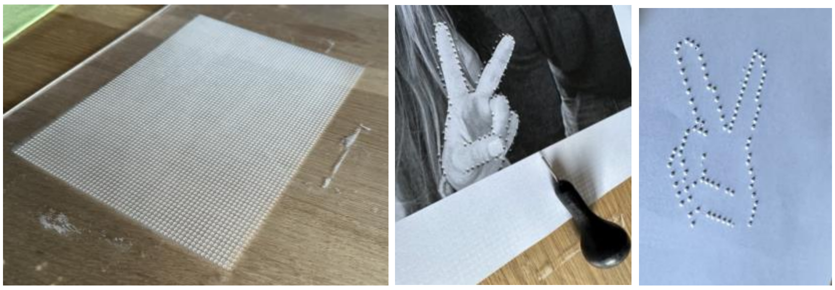

Fig. 2. Acrylic laser cut template (left), picture of the punching tool, and the image as it is when punched (center), as well as a picture of the generated tactile image (right).

Materials for several potential scenarios were prepared to try out the technique: photos from social media, shopping images and maps. The procedure for preparing the images was the following:

1. Mirror image in drawing program
2. Print on paper in appropriate size
3. Put on embossing template
4. Punch holes / dots (Fig 2 center)

Images were prepared with dots representing different things: in the map case, for example, dots could be outlines (coast / borders), land mass or ocean, depending on the use of the map. As the paper images would be very easy to accidentally move, and the lo-fi-prototype should be experienced as a "device", images were put on cork boards with thumbtacks. The device had two parts, one for the pin display and one with a Braille keyboard and other input. These could be freely moved to discuss the preferred layout of these in a finished system.

Feedback for the device during the workshops was generated by a "human computer" (Wizard of Oz method). As such, when the participant places a finger on the pin display, the computer gives verbal feedback about what is under the user's finger. As in the envisioned device this feature can be turned on and off. To further encourage participants to contribute their ideas, a set of "buttons" (small foam shapes) to put on the "device" were included.

5 Testing the materials

Three users from the local organization for persons with visual impairments in Sweden, SRF, participated in a pilot workshop. The participants were Braille readers; between 37 and 54 years of age; two male and one female. For the tasks in the workshop, we decided to use one map task, representing more schematic graphics, and one photo task, representing all the different types of photo images uses meet on social media, while shopping etc. The map selected was Antarctica, since we wanted to avoid users being influenced by local knowledge in the task. For the photo, we selected a social media image of a group of people taking a selfie. For both types of images users were asked to discuss how zooming, panning, but also annotation should be performed. In addition, for the map, we discussed legends, while for the photo, we discussed the filtering out of image elements.

In general, the materials were seen to work well. There was a lively discussing during the different tasks, and users also interacted with the different prototypes as intended, allowing us to, together with the users, explore what worked and what didn't. The voice feedback generated by the wizard of oz, was seen to be helpful, and one of our users specifically commented that they now had a much better understanding of what the system might be like. The only "problem", if we can call it that, was that the human computer, which was responsible for providing feedback, as well as for updating the screen, i.e. changing the embossed images when the users zoomed in or panned, was deemed to have a slow update rate ("smart but slow" was one user comment about the human computer).

Interaction with the materials during the workshop showed how hard it can be to understand pin renderings of images,. The importance of being able to provide the user with additional feedback depending on where they touch, as well as to provide good overall descriptions, was highlighted. At the same time, we noted a challenge in providing feedback during the exploration, since our users tended to use several fingers when exploring, something which at times made it difficult to know exactly what object/feature to provide feedback for. Users liked to use voice commands, as well as buttons and gestures, although for gestures, it was pointed out one should adhere to existing standards as much as possible (blind persons must learn enough as it is, and having to re-learn new gestures would not be appreciated). The importance of being able to select, filter or focus on specific objects or features was pointed out. The amount of information easily becomes too much, and the ability to focus on a single feature as for example, the hand sign in Fig 2, right, would be helpful. Knowing where you are after an operation like zooming or panning was seen to be important. Finally, one needs to keep in mind that this isn't always about just exploring an existing image, sometimes you will need to annotate or add information yourself.

6 Discussion and conclusion

In general, the materials supported different types of discussions around the future interactions with the, not yet existing, device, and thus, well fulfilled the requirements for being a good lo-fi material for a co-design activity [8]. Compared to both [5] and [6] our paper prototyping targets a pin display with custom pin distances, instead of widgets, making use of custom/handmade paper pin prototypes. We also focus more on multimodal interaction, leading us to rely more heavily on a wizard of oz style of interaction.

One inherent challenge in all design aiming at translating visual information into non-visual information, is that vision is a sense that can handle massively parallel/simultaneous information. While both hearing and touch can handle some simultaneous information, the bandwidth is significantly smaller, and larger amounts of information is typically transferred sequentially, e.g. by touch exploration over time, or by listening to a description. This is something anyone designing for the non-visual senses need to take into account.

Another challenge, more specific to tactile displays, is the fact that 2D graphics like photographs, drawings, etc., are 2D representations of 3D objects and environments. This involves conventions that often need to be learned, especially if you have a visual impairment. An example from the HIPP project [10], is the case where a blind pupil was asked to draw a wheel, and initially drew a rectangle, since this person had felt wheels by gripping them from the front (from this perspective the wheel is indeed well represented by a rectangle). In contrast, the visual 2D convention for drawing a wheel is a circle, which is what a sighted pupil typically would draw. Combined with the limited tactile bandwidth, this indicates that additional information is typically needed to support the user in the interaction with tactile graphic information. This theme came through in our workshop quite clearly. Additional information, both as image descriptions and overviews, as well as feedback during the exploration was seen to be a great help. This points to the importance of having a display that not only presents tactile images, but is able to provide descriptions, and also can track where the user is, in order to provide feedback as response to touch or gestures.

The use of several fingers for exploration is well known [3], and using the generated lo-fi materials to discuss different solutions of how feedback during exploration could be provided was productive, as was the discussions on zooming, panning, filtering etc.

To conclude: in this paper we present a novel way of generating lo-fi materials for a specific type of device, a tactile refreshable pin display. Using this kind of materials was seen to work well during a pilot test, and the presented material design will be used in future co-design activities within the ABILITY project in order to generate novel design recommendations for the system to be developed.

Acknowledgments. We want to thank all the users participating in our different user studies. Furthermore, we gratefully acknowledge support from the EU for the project 101070396 - ABILITY.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Ehn, P.: Work-Oriented Design of Computer Artifacts. (1988).
2. Holloway, L. et al.: Animations at Your Fingertips: Using a Refreshable Tactile Display to Convey Motion Graphics for People Who Are Blind or Have Low Vision. In: Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility. Association for Computing Machinery, New York, NY, USA (2022). https://doi.org/10.1145/3517428.3544797.
3. Jansson, G., Monaci, L.: Exploring Tactile Maps with One or Two Fingers. Cartogr. J. 40, 3, 269–271 (2003). https://doi.org/10.1179/000870403225012989.
4. Magnusson, C. et al.: Co-designing together with Persons with Visual Impairments. In: Pissaloux, E. and Velazquez, R. (eds.) Mobility of Visually Impaired People:

Fundamentals and ICT Assistive Technologies. pp. 411–434 Springer International Publishing, Cham (2018). https://doi.org/10.1007/978-3-319-54446-5_14.
5. Miao, M. et al.: Tactile Paper Prototyping with Blind Subjects. In: Altinsoy, M.E. et al. (eds.) Haptic and Audio Interaction Design. pp. 81–90 Springer, Berlin, Heidelberg (2009). https://doi.org/10.1007/978-3-642-04076-4_9.
6. Prescher, D. et al.: A tactile windowing system for blind users. In: Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility. pp. 91–98 Association for Computing Machinery, New York, NY, USA (2010). https://doi.org/10.1145/1878803.1878821.
7. Rettig, M.: Prototyping for tiny fingers. Commun ACM. 37, 4, 21–27 (1994). https://doi.org/10.1145/175276.175288.
8. Sanders, E.B.-N., Stappers, P.J.: Co-creation and the new landscapes of design. CoDesign. 4, 1, 5–18 (2008). https://doi.org/10.1080/15710880701875068.
9. Schmitz, B., Ertl, T.: Interactively Displaying Maps on a Tactile Graphics Display. Presented at the (2012).
10. Szymczak, D. et al.: Dynamic multimodal drawing in school: Exploring technology support of drawing skills development in children with visual impairments. Technol. Disabil. 31, 3, 83–99 (2019). https://doi.org/10.3233/TAD-190224.
11. Dot Pad — The first tactile graphics display for the visually impaired., https://pad.dotincorp.com/, last accessed 2023/06/13.
12. Meet Monarch, https://www.aph.org/meet-monarch/, last accessed 2023/06/13.