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BAYREUTH**

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Prof. Dr. Jörg Müller

Big Master Project

The Haptic Printer

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Abstract

Over the years of evolution of human computer interaction, we have seen various kinds of interaction techniques. The recent trend of contactless haptic technology has been on the rise. In our project we focus to render custom shapes on the user palm, using different kinds of rendering techniques. The main objective of this project is to map various kinds of user input like CSV, SVG, drawing from canvas and inputs from leap motion. We consume these inputs and process them in order to render custom shapes. Also, this report analyse and compare the different techniques of rendering with various validation techniques and deduce an overall result from the study and implementation of the proposed application.

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Introduction

The haptic technology enables human computer interaction in a new way compared to previous existent interaction techniques. Haptics gives us a new dimension of interaction technique without any physical contact between the user and the device. This contactless haptic technologies give rise to various kind of applications in real life scenarios. One prominent among them is the mid air user interfaces, where the use of hand and finger movements are used to control the interface. Ultrasound haptic technology [ITS08] is one of the example of contactless haptic technology where ultrasound waves are emitted by the device and coincide at a particular point in space to give haptic sensations.

1.1 About Ultrahaptics

The human skin has mechanoreceptors which are sensory cells that convert mechanical forces into nerve excitation. When the sound waves make contact with the skin, it gives a tactile sensation for the user. In order to produce such ultrasound waves we make use of a device manufactured by Ultraleap [UI] called as Ultrahaptics. The device emits ultrasound from its phased array which propagates as a wave with a frequency higher than the limit of human hearing. Each emitter in the device emits the wave and every wave emitted coincide at a point in the air. This coincidence of the waves at a point is called a focal point and this focal point when directed towards a user palm creates a pressure for the user and the user can perceive it as a tactile sensation. The coincidence of waves at a focal point, strength and intensity of each transducer is handled by the Ultrahaptics device itself by using various solver algorithms.

In order to render custom shapes we need to explore various techniques of rendering and experiment with different parameters of the device. The different parameters available in the device are intensity, frequency, multiple focal points and the different techniques of rendering are explained in the next section of literature survey.

1.2 Project objective

Using the concept of mid air interfaces, we can explore and build many applications in our real world. In the recent times due to the COVID-19 pandemic, one prominent use case would be to build contactless interfaces in the public space. In order to achieve this we need to render custom shapes to the user in order to make user aware of different kinds of sensation. In this project, our main focus is to render custom shapes on user's palm using different kinds of inputs. Here, different kinds of inputs means different various formats like CSV (comma-separated values), SVG (Scalable Vector Graphics), user drawing and Leap Motion. We process all these kind of inputs and render the dynamic shapes using the Ultrahaptics device.

Related Work

” *A picture is worth a thousand words. An interface is worth a thousand pictures.*

— **Ben Shneiderman**
(Professor for Computer Science)

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2.4 Conclusion

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Features

“Users do not care about what is inside the box, as long as the box does what they need done.

— **Jef Raskin**

about Human Computer Interfaces

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3.1 Concepts Section 1

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3.2 Concepts Section 2

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Architecture

” *Innovation distinguishes between a leader and a follower.*

— **Steve Jobs**
(CEO Apple Inc.)

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4.1 architecture Section 1

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Fig. 4.1: Figure example: (a) example part one, (c) example part two; (c) example part three

This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

4.2 architecture Section 2

And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there

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Fig. 4.2: Another Figure example: (a) example part one, (c) example part two; (c) example part three

After this fourth paragraph, we start a new paragraph sequence. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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4.3 architecture Section 3

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4.4 Conclusion

This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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Validation

After the development of our web application it was time for validation to check how the custom shapes are being rendered from the Ultrahaptics device. In order to validate our rendered shapes we shortlisted three different techniques which are explained in detail in the following sections.

5.1 Ultraviz tool

The Ultraviz is a tool developed by Ultraleap [UL][Ult] to visualize control points that are being rendered by the Ultrahaptics device in a three dimensional space. It helps the developer to understand how the rendering is happening visually. With the help of this tool we tried to analyse the different rendering techniques like AM and TPS with different kind of inputs i.e, CSV, SVG, drawing on canvas, live leap motion and drawing on canvas with the help of leap motion.

The following are the various kinds of inputs we tried to render:

Note: Since the images are screenshots of the Ultraviz visualization tool, we cannot see all the control points being rendered in the image as it is moving at a high speed.

1. Read CSV file feature:

The x and y coordinate values are read from a CSV file and the plot is as shown in Fig 5.1. This plot will be rendered in the Ultrahaptics device. Fig 5.2 (a) represents the CSV plot being rendered on Ultrahaptics using AM technique and Fig 5.2 (b) represents the same CSV plot in TPS technique.

2. SVG file input feature:

Fig 5.3 depicts the various SVG files used to render on Ultrahaptics device. Once the SVG files are uploaded it is converted to x and y coordinate system with many points. Fig 5.4 shows the different xy plot of the SVG files uploaded.

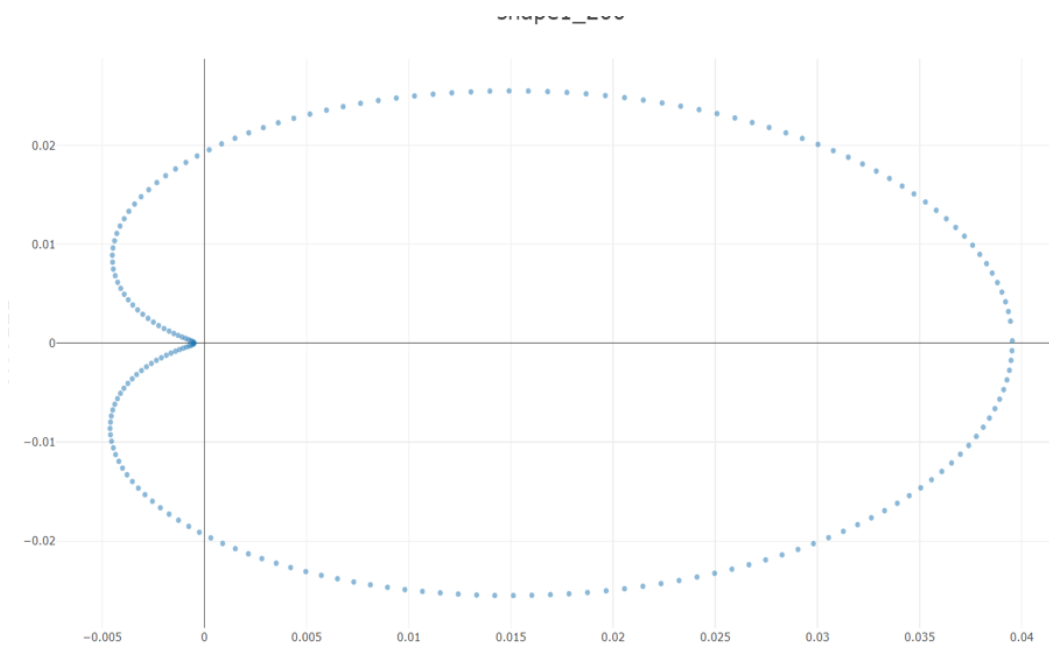


Fig. 5.1: CSV Plot of a custom shape

Fig 5.5, Fig 5.6, Fig 5.7 displays an image of Ultraviz tool rendering the SVG inputs arrow down, WiFi and square in AM and TPS technique respectively.

3. Drawing on canvas:

The user can draw the shapes on the given HTML canvas using mouse. Fig 5.8 (a) shows a user drawn circle shape and Fig 5.8 (b) shows an plot of the user shape represented in x and y coordinate which will be eventually rendered on Ultrahaptics.

Fig 5.10 (a) depicts the rendering of custom user shape in Ultraviz in AM and Fig 5.10 (b) depicts the same in TPS technique.

4. Leap Canvas:

Leap canvas is similar to canvas drawing, instead of using mouse as a drawing tool here we use our index finger and with the help of Ultraleap leap motion device we draw on the canvas. Later the canvas drawing is converted to xy plot and then rendered on the Ultrahaptics device.

5. Leap Live:

Leap live uses the Ultraleap leap motion device to track our index finger and the same point is being rendered live on the Ultrahaptics device. The control point moves in the direction of the Ultraleap leap motion hand input.

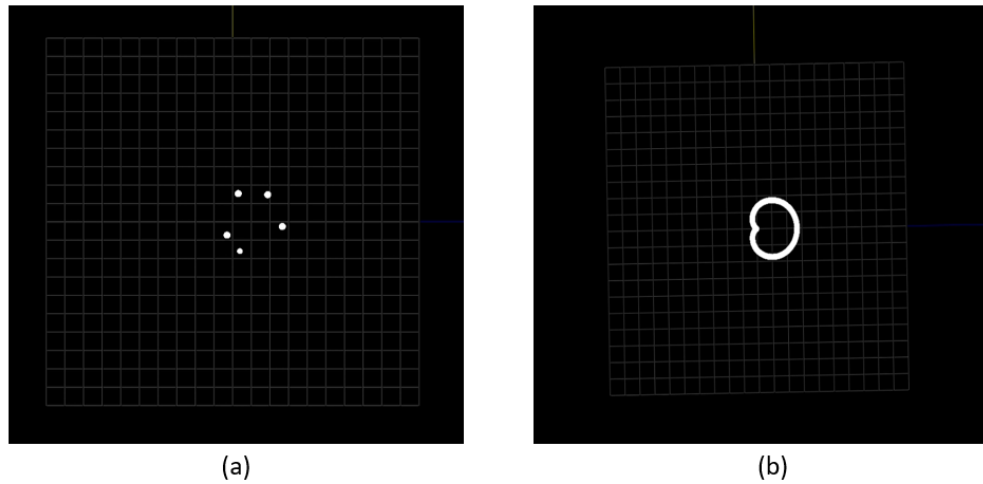


Fig. 5.2: (a) Ultraviz visualization of CSV plot in AM and (b) TPS technique

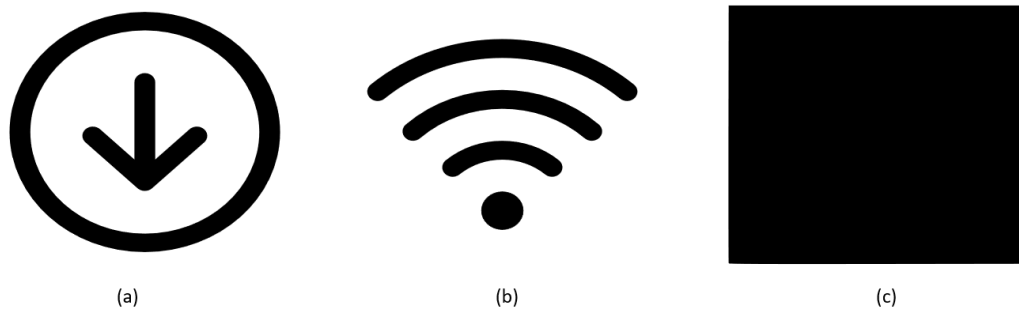


Fig. 5.3: SVG input shapes (a) Arrow Down (b) WiFi (c) Square

5.2 Cross validation and observation from developers

In order to further validate our project we conducted a short study between the authors of this project where we chose three different shapes i.e, square, circle and triangle and decided to guess the shape in various different techniques. In the first study we did not tell the observer on the Ultrahaptics which all shapes where there in the study and the observer guessed everything as circle.

Later in the second study, we informed the observer the available shapes and then performed the study. We conducted the study mutually between us and below are the results: Square shape was easily identified by both of us in AM technique and both guessed the square shape as circle in TPS technique. Triangle was guessed correctly in both the techniques. Circle was guessed correctly in TPS technique and one observer reported circle as triangle in AM technique.

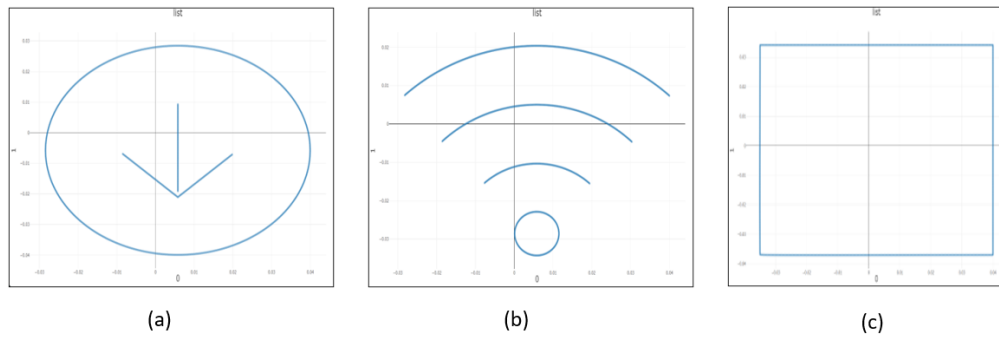


Fig. 5.4: SVG plot of input shapes (a) Arrow Down (b) WiFi (c) Square

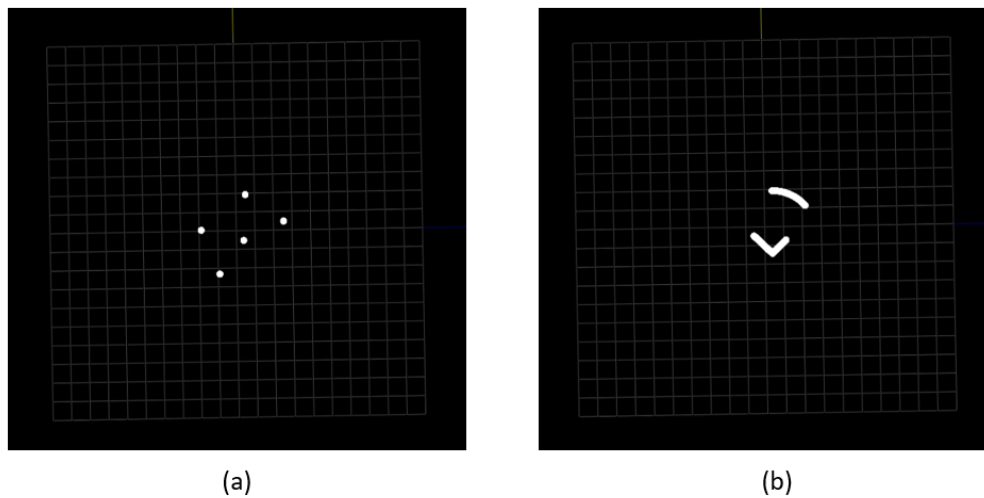


Fig. 5.5: (a) SVG rendering of arrow down in AM (b) SVG rendering of arrow down in TPS

Below in Fig you can see all the results summed up in a table.

5.3 Oil bath

We also came across a technique where the rendering can be projected on a oil bath to see how the inputs where being rendered on the user palm [Oil]. The step by step guide to set up the environment is as follows:

1. The Ultrahaptics device is suspended approximately 15cm above the oil bath using a robotic arm. There is no need to use the Leap Motion so the cradle can be separated.
2. The oil is between 2 and 5mm deep. There is a purpose built perspex tank of 30 centimetres for the experiment. The oil must have the correct consistency and

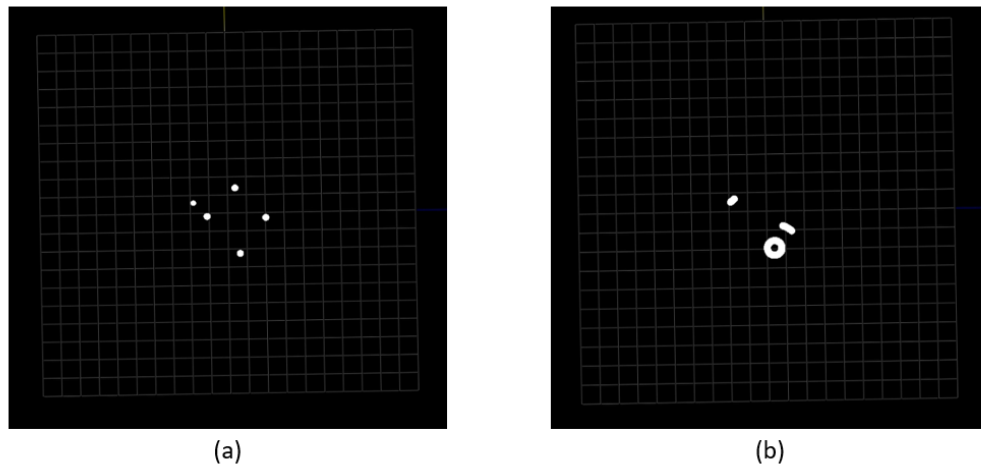


Fig. 5.6: (a) SVG rendering of WiFi in AM (b) SVG rendering of WiFi in TPS

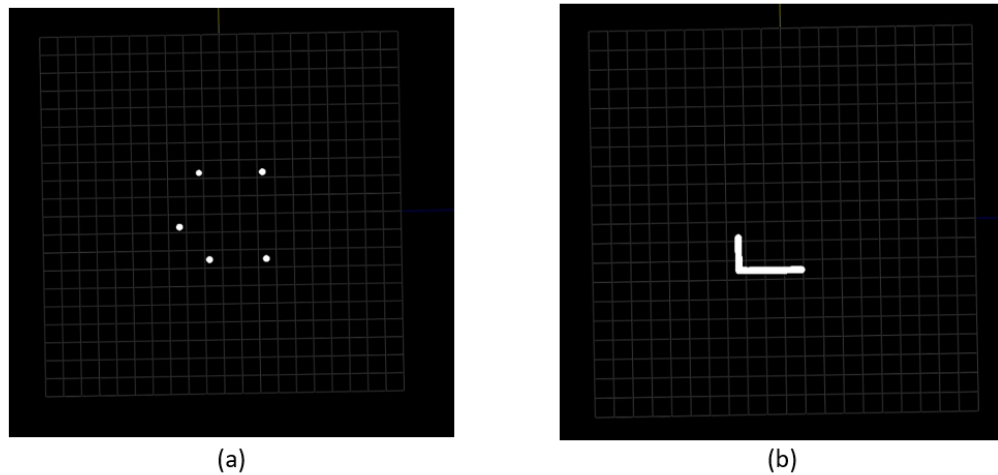


Fig. 5.7: (a) SVG rendering of square in AM (b) SVG rendering of square in TPS

viscous enough to show dispersion, fluid enough to be responsive. We have found that a 50:50 mix of olive oil and pumpkin seed oil give good results.

3. The oil bath must be raised approximately 3 cm above a white surface. We used legos for this purpose and used two A3 sheets of paper as a white surface.

4. Light with a single, small, bright light source from above or to an angle to project the shadow of the distorted surface on to the oil. There is a small, LED light available on an adjustable stalk. Place it between top of tank and perspex holder, with light covering as much of oil as possible. The light must be bright enough to reflect onto a wall and the room must be as dark as possible to achieve the best affect.

Fig 5.11 and Fig 5.12 show the experiment setup of oil bath.

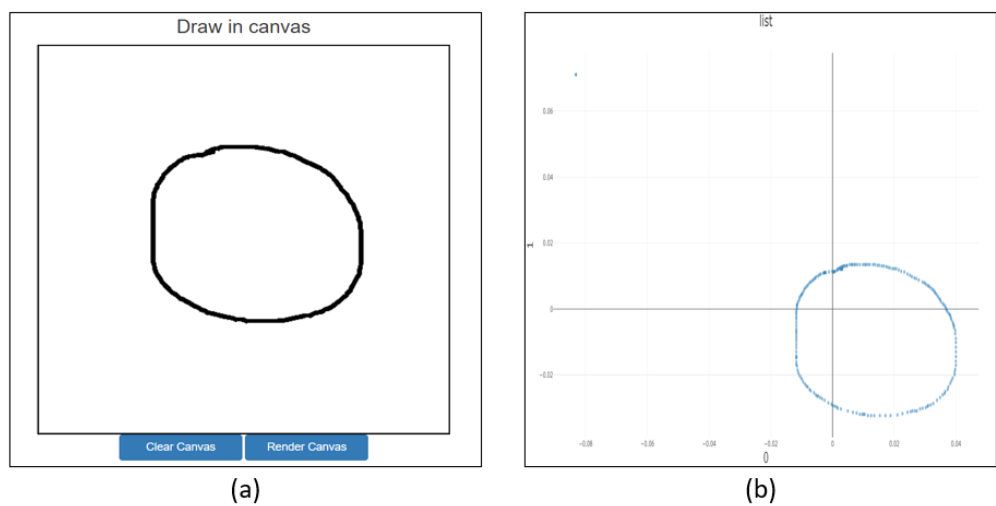


Fig. 5.8: (a) User drawn circle shape on HTML canvas (b) XY plot of the given user shape

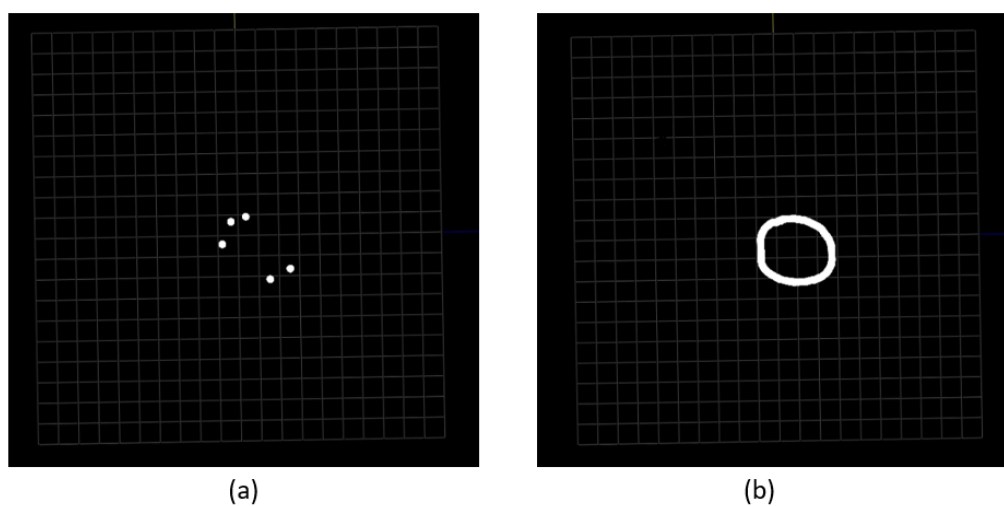


Fig. 5.9: (a) User drawn circle rendering in AM technique (b) User drawn circle rendering in TPS technique

Observer: Anuj			Observer: Akshaya		
	Amplitude Modulation	Time Point Streaming		Amplitude Modulation	Time Point Streaming
Shape			Shape		
Square	Yes	Answered as circle	Square	Yes	Answered as circle
Circle	Yes	Yes	Circle	Answered as triangle	Yes
Triangle	Yes	Yes	Triangle	Yes	Yes

Fig. 5.10: Results of validation between the authors of the project

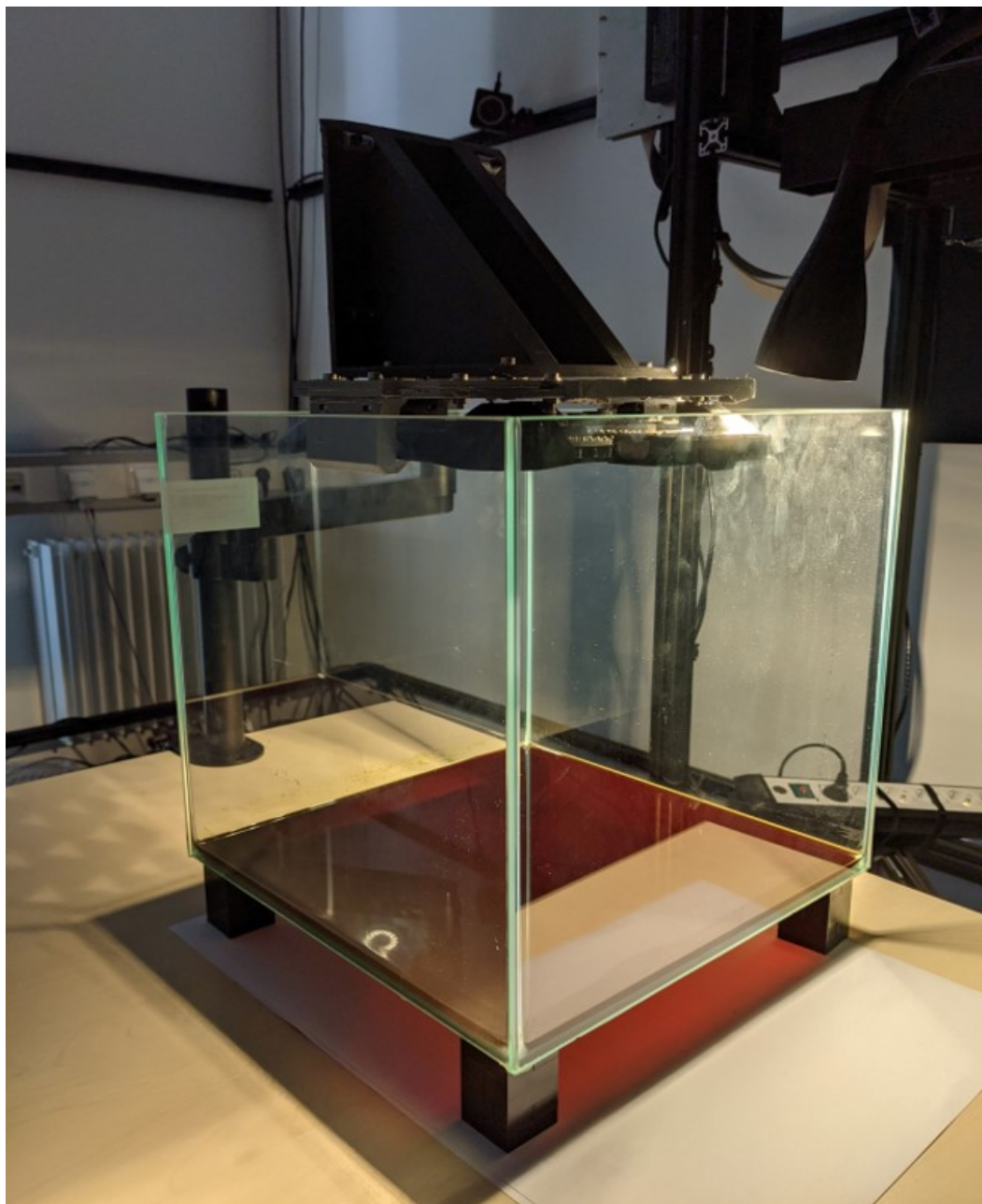


Fig. 5.11: Overall oil bath setup

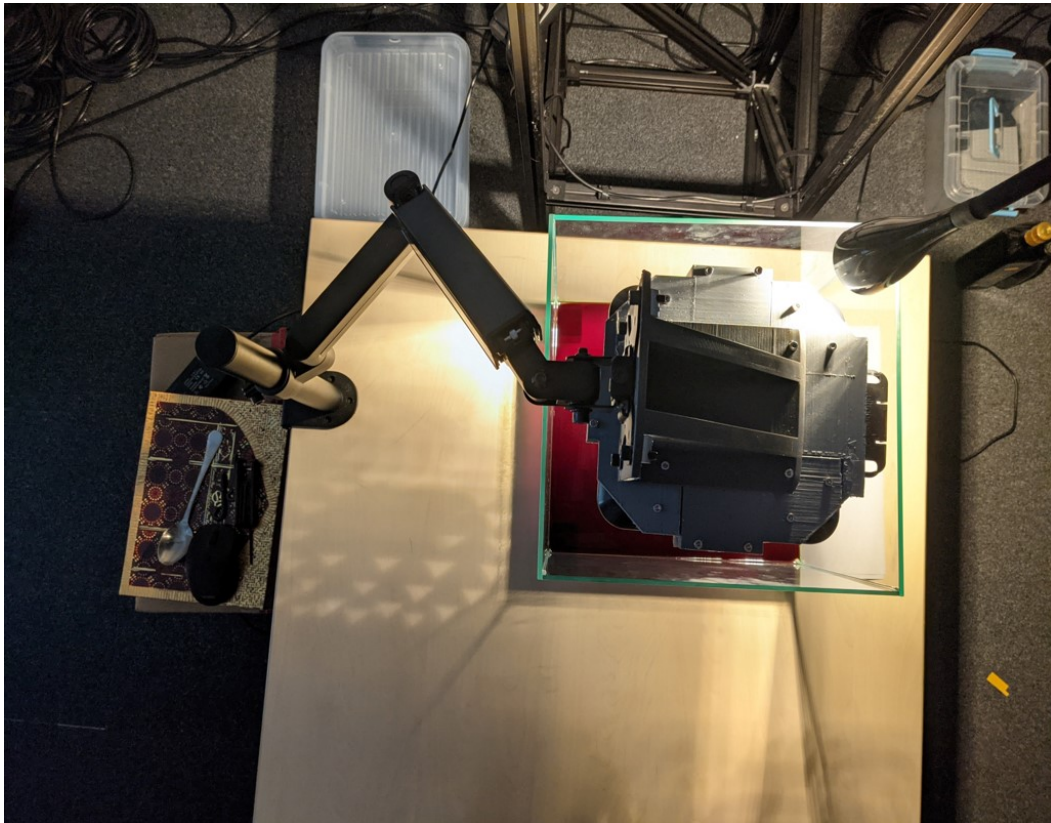


Fig. 5.12: Top view of oil bath setup

Conclusion

You can put your declaration here, to declare that you have completed your work solely and only with the help of the references you mentioned.

Bayreuth, September 27, 2021

The Haptic Printer

Future Work

You can put your declaration here, to declare that you have completed your work solely and only with the help of the references you mentioned.

Bayreuth, September 27, 2021

The Haptic Printer

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Declaration

I declare that this project, was solely undertaken by myself. All sections of the report that use or describe an concept developed by another author are referenced.

Bayreuth, September 27, 2021

The Haptic Printer

