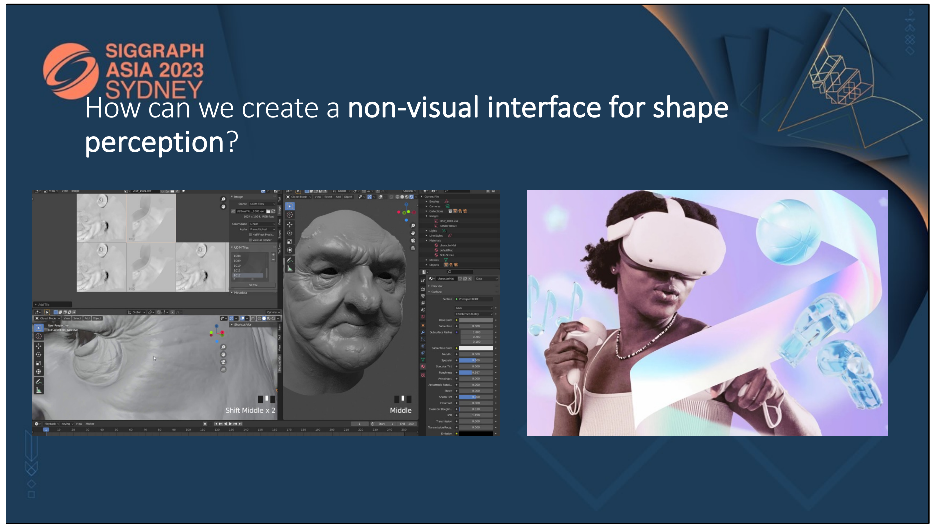
Good afternoon, My name is Jialin Huang
and today I'm gonna share the work done by me and Prof. Rana Hanocka from University of Chicago, researcher Alexa siu from Adobe research and My advisor Professor Yotam Gingold.



Traditional computer graphics build the connection between real shapes with shapes shown on 2D screen even 3D in XR devices with visual feedback. However, how could ***blind*** people see virtual 2D and 3D shapes?

we can design interfaces rely on other feedback like tactile, auditory, rather than visual.

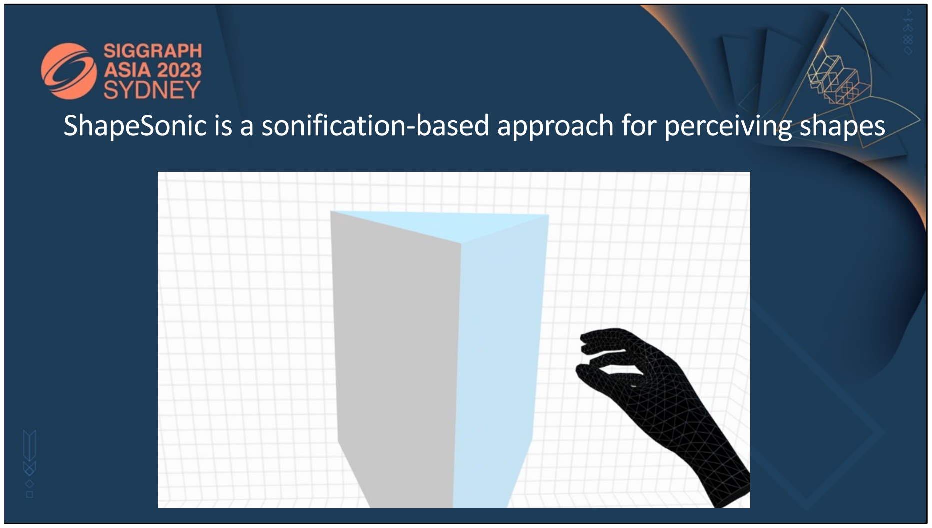
There are some works done for this purpose and they designed the program to provide tactile feedback like it in the real world.

For example, the work of Panotopoulou fabricated the illustration by popup lines to mimic the curvature and geometry of 3D shapes.

The second work shows the device created by Siu which can roughly simulate 3D shapes as heightmaps of pins.

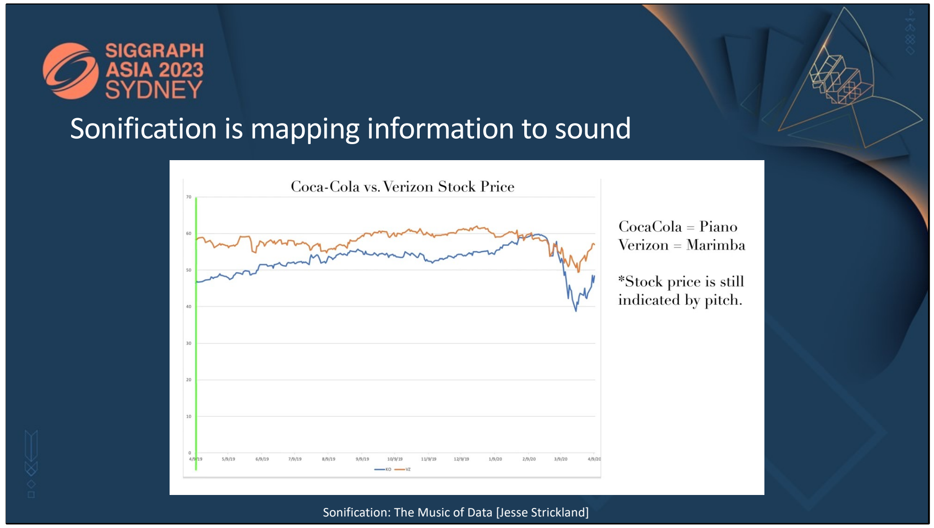
However, compared to Auditory, interfaces rely on haptic feedback need specialized devices or fabrication process.

These interfaces are less available and less suitable for real-time feedback and interaction .



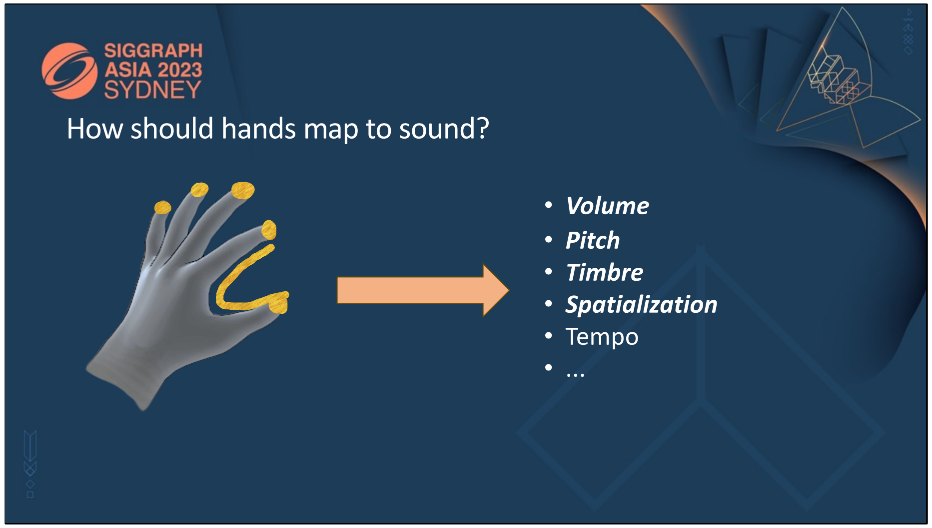
So we designed an interface, called ShapeSonic, which uses only auditory feedback.

(click video)specifically, ShapeSonic is a sonification-based approach for shape perceiving.



What is sonification?
Sonification is the use of non-speech audio to convey information or perceptualize data.

There is an example about perceptualizing line chart. (click)By this, you can perceive the data by the tone and timbre of two sounds.



In our design, we use the handtracking of the oculus to track the movement of fingertips.
We want to map hands to sounds, but how?

In the design space of hands, we tried interaction with only fingertips(click), or whole hands(click). We also tried use the curvature of hands(click).
(click)we chose to use only the position of ten fingertips, which is clearer to users during our trials.

In the design space of sounds features, we chose (click) volume, pitch, timber, and spatialization.

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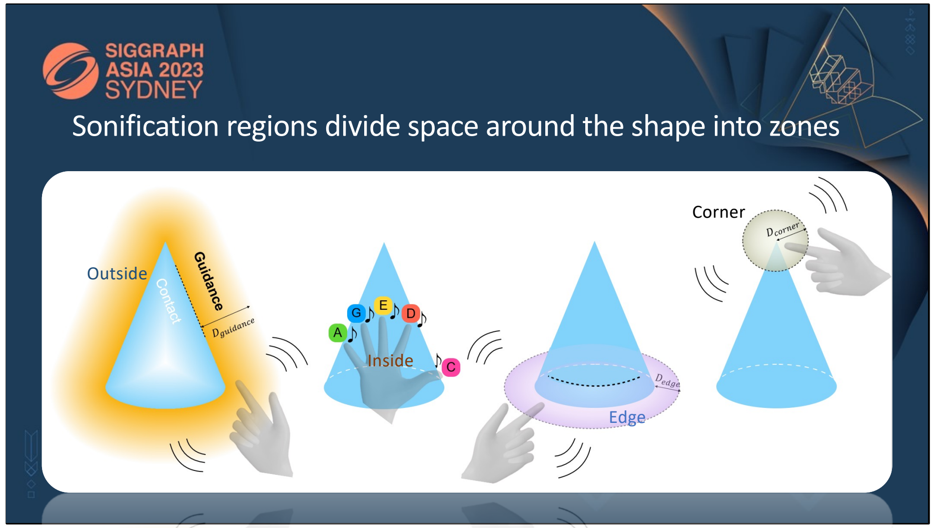
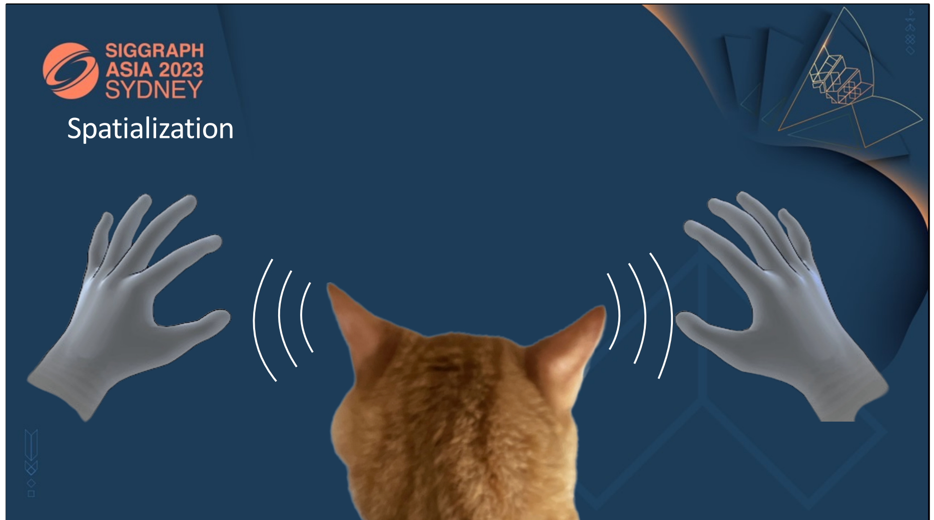
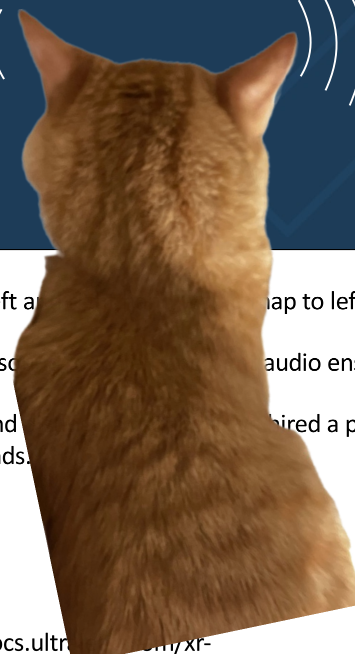


In detail, the sonification regions in our design divide space around the shape into zones.
Here, there are (click)outside, (click)inside and (click)space around sharp edges and corners.
In each zone, there are different sonification design.





Also, Sounds triggered by left a ... ap to left and right ear to indicate the direction.
Compared to stereophonic sc ... audio ensures an unambiguous mapping from hands.
Also, To provide pleasant and ... ired a professional sound designer to design our sounds.

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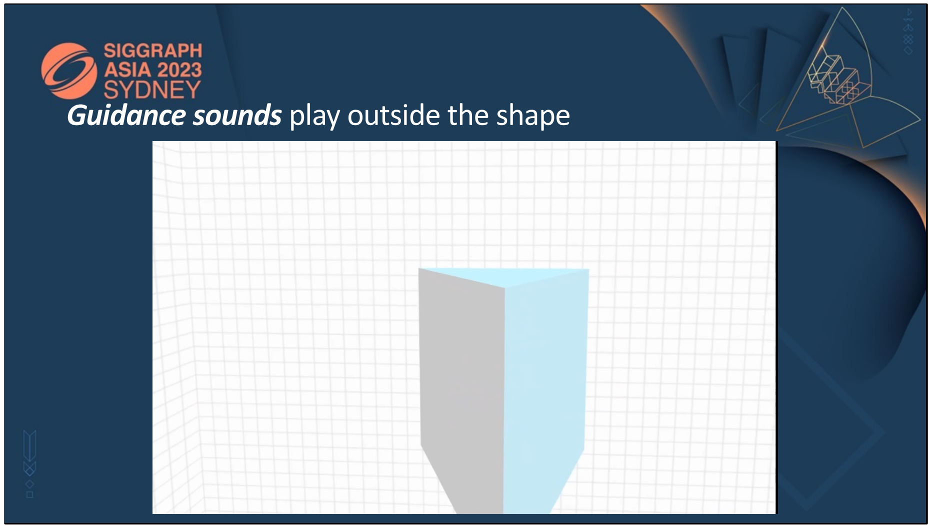
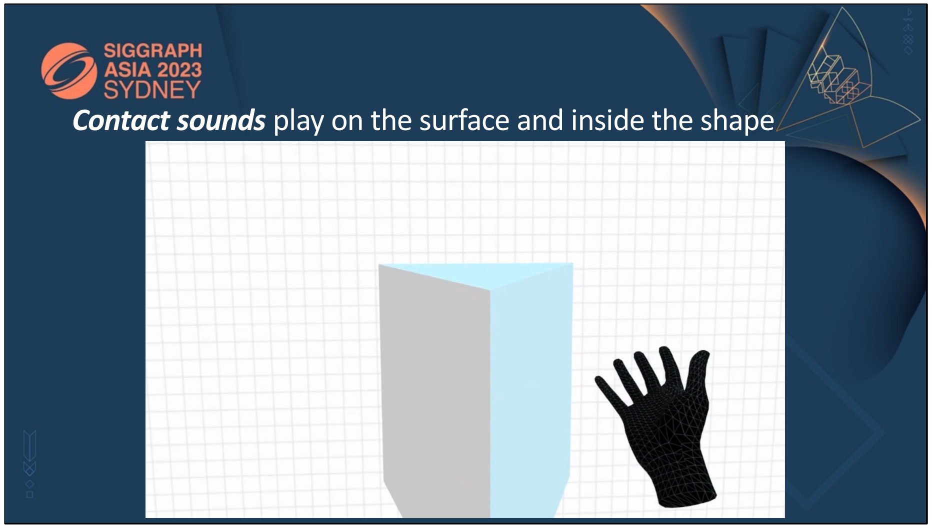
In detail, I will show the designs of four sounds in the following page.
(click) The first one is the guidance sound



The guidance sound will only play outside of the shape. The closer the fingertips to the shape, the louder the sound.
(click) This sound can guide the users toward the surface of the shape from the outside.

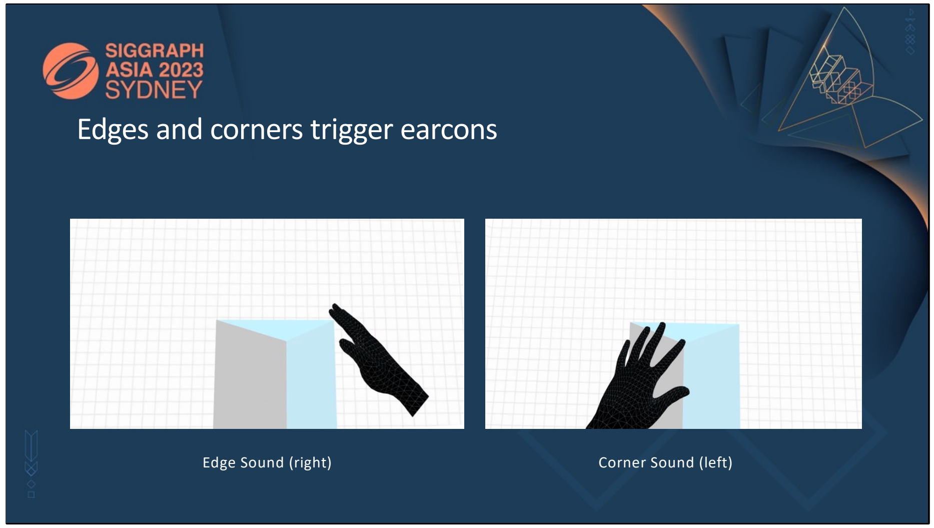
（click） The second sound is contact sound,



It plays when fingertips get on the surface or into the shape.
And fingertip contact maps to a pentatonic scale.

This gives the user the ability to detect whenever a fingertip comes in and out of contact with the surface of the shape.

(click) The third and fourth sounds are edge sound and corner sound.

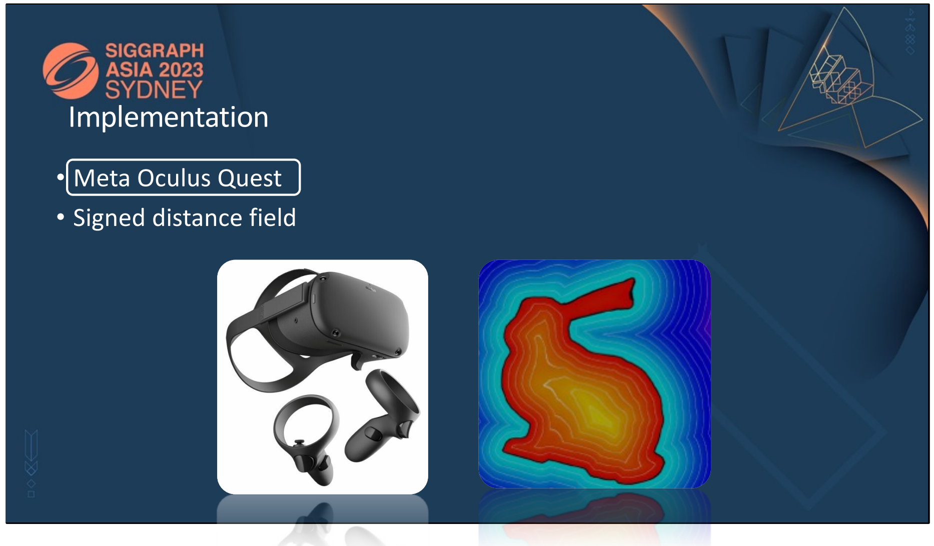


they play around the sharp edges and corners respectively

We use earcons for sharp edges and corners.

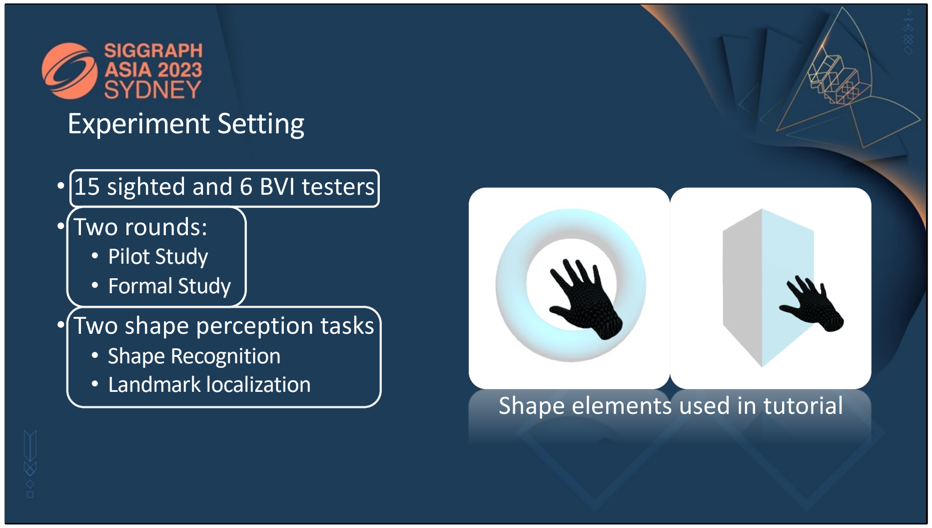
Touching an edge plays a sound resembling a plucked guitar string. (click)

Touching a corner plays a bell-like sound.(click)



Implementing ShapeSonic requires reliable hand tracking, stereo headphones, and fairly light computing needs

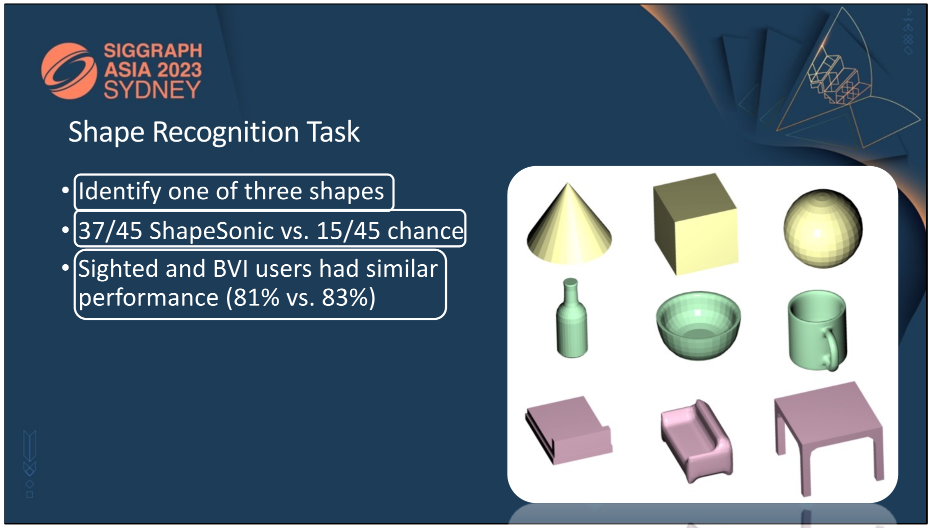
We chose the widely available and affordable Oculus Quest VR headset



(click)After our designing and implementing,
We evaluated ShapeSonic with 15 sighted and 6 BVI users
(click)We invited 6 sighted people for pilot study
after improving some sonification designs and the setting of study,
we invited 9 sighted and 6 bvi users to join the study.

The study protocol began with a 10-minute tutorial and training period,
we guided participants to hear all forms of sonifications and taught them basic strategies via exploring the torus and prism.

(click) The user study has two tasks: shape recognition and landmark localization



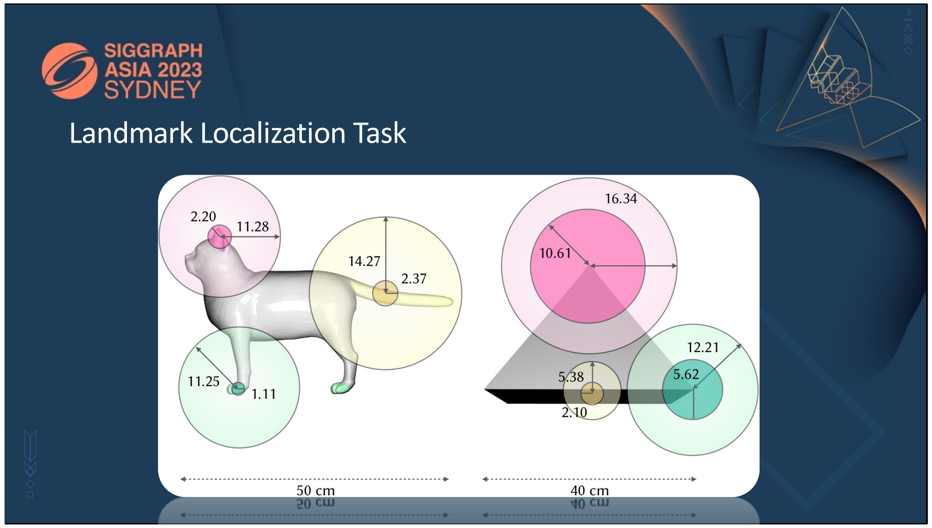
In shape recognition task of formal study, there are totally three rounds, in each round, they would explore with one of three shapes in one row randomly.

Before each round, participants were given a brief description of three shapes, and after exploring, they were asked to identify which shape it was.

(click)

In the overall 45 trials in the formal study, they successfully identified 37 times, which is much higher than 15 times as random guessing

(click)Also, from the result, we can see sighted and BVI users got similar performance, which means ShapeSonic is effective in allowing both sighted and BVI users to identify shapes.



In landmark localization task, we provided a verbal description about the shapes, and we asked participants to touch each landmark without sonification, which provided a baseline for comparison.

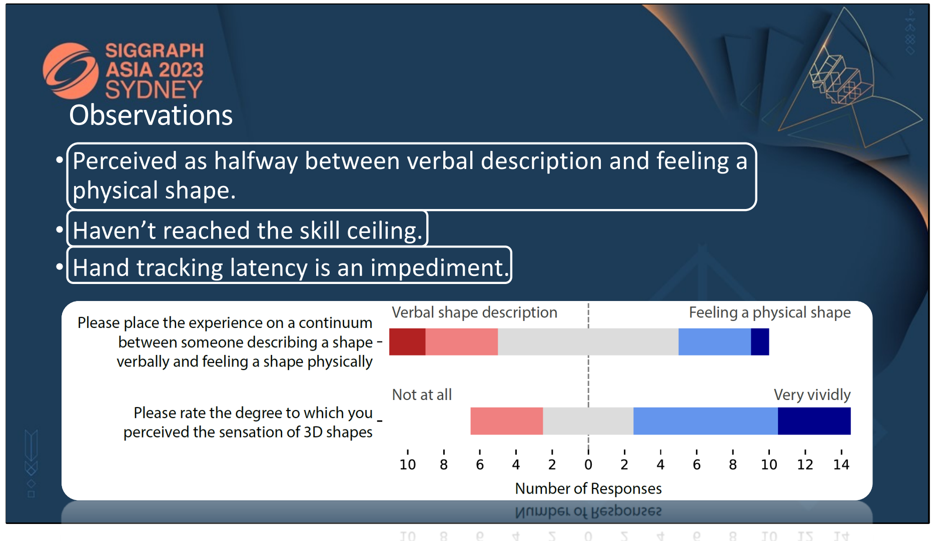
After that, they were asked to relocated landmarks after five minutes interaction with sonification.

The figure shows the improvement in landmark positioning error when using sonification.

Sonification improved landmark positioning accuracy for all features.

We found no significant overall differences between sighted and BVI participants.

Two participants who both were bvi from birth showed exceptional improvement when using our sonification.



After the study, we asked participants to finish a questionnaire about their feelings.
Participants perceived the experience halfway between verbal description and feeling a physical shape.*/We believe both verbal and sonification information are necessary for successful perception

requested more sound feedback to provide additional information.
In our observation, all could learn the meaning of all sounds when they did the second task, which means we haven’t reached the end of training phase.

Also, The hand tracking latency forces users to move slower than they otherwise might.

Extremely low latency interactions may provide a sensation akin to “ear haptics,” where the tactile sensation is transferred.

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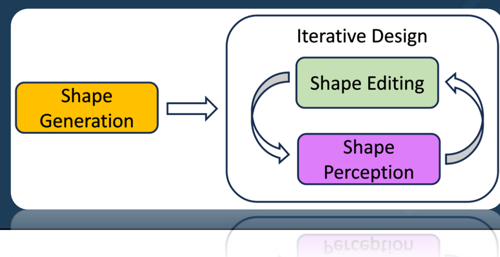
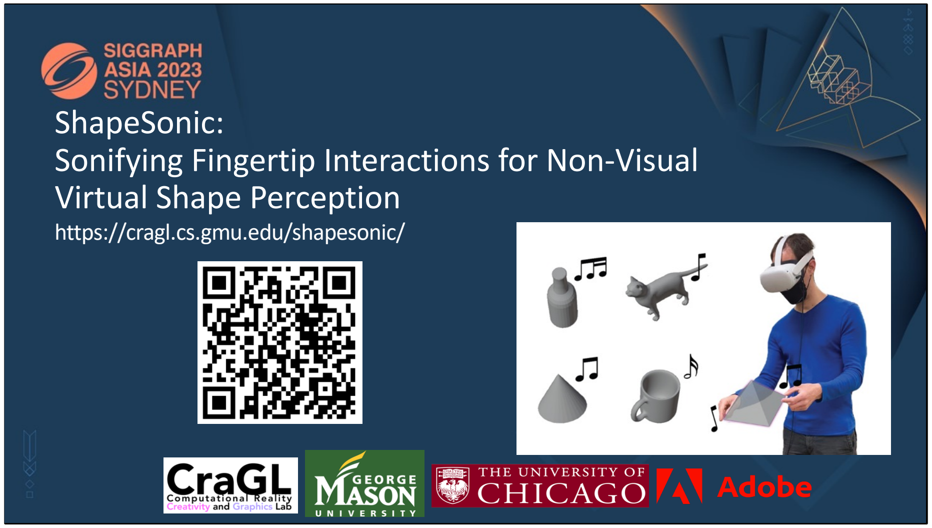
Future Work

- Physical attributes
- Complex objects and scenarios
- Non-visual 3D shape design framework





Thank you for listening and come to my q&a session to try the sonification if you are interested!