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Curvature Discrimination for Dynamic Ultrasound Mid-Air Haptic Stimuli

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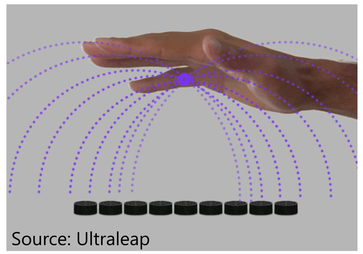
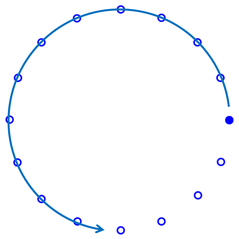
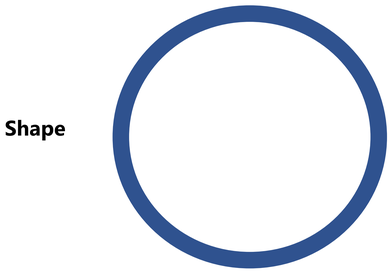
CONTEXT

- Adding a sense of touch in extended reality
- Tactile rendering of geometric shapes by focusing ultrasound waves to create a focal point and move it along the shape


Source: Ultraleap

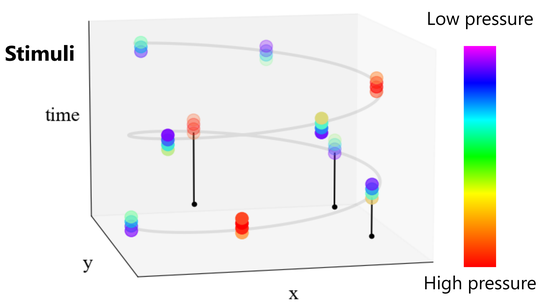


- Sampling strategies change how a rendered shape feels



Applying a sampling strategy

- The shape is sampled
- Points are ordered
- A pressure level is set for each point



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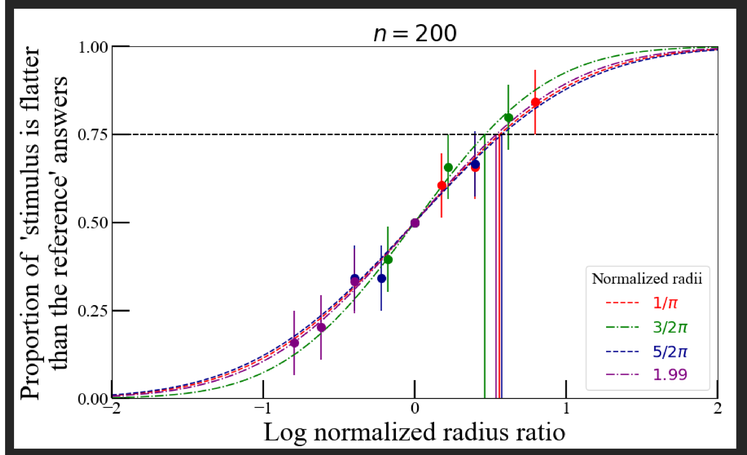


The data was fitted to a cumulative Gaussian to estimate the 75% JND. Here is the result with the 200 points strategy

	10	50	200	400	800
$1/\pi$	3.46	3.4	3.63	4.32	3.81
$3/2\pi$	4.01	3.61	2.91	6.37	7.84
$5/2\pi$	3.83	3.53	3.78	3.94	5.85
1.99	4.15	3.85	3.46	5.31	7.72

JND estimates for each strategy (column) and reference normalized radii (row)

- ➢ Curvature discrimination is possible with ultrasound mid-air haptics, albeit quite difficult
- ➢ At first glance N does not seem to impact curvature discrimination performance much
- ➢ Next we will check if the differences in strategy are significant. We will also explore other geometric properties and sampling parameters. Finally we will measure the JND in curvature for static stimuli

USER STUDY

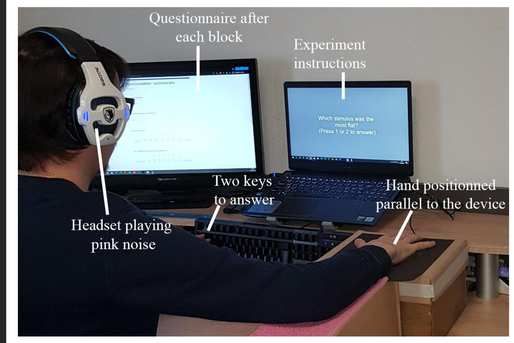
Goal

- Is curvature discrimination possible with ultrasound mid-air haptics?
- Does the number of sample points have an impact?

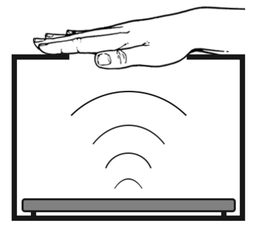
Protocol

The user was presented with successive pairs of arc-shaped stimuli, with a tactile pointer moving along the arcs, and then asked which one felt the flattest

- 5 blocks for the different strategies
- 4 different curvatures
- 19 volunteers



Experimental setup



ANNEXES

DOLPHIN: Stimulus design framework (open-source)
https://gitlab.com/h-reality/dolphin

Psychopy: Experiment design tool (open-source)
https://www.psychopy.org/