QoE Assessment of Angle Perception with Haptics for Networked Virtual Environments

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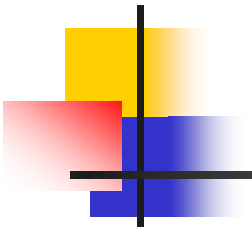


Outline

- Background
- Previous Work
- Angle Perception System
- Experiment Method
- Experimental Results
- Conclusion and Future Work

Background (1/2)

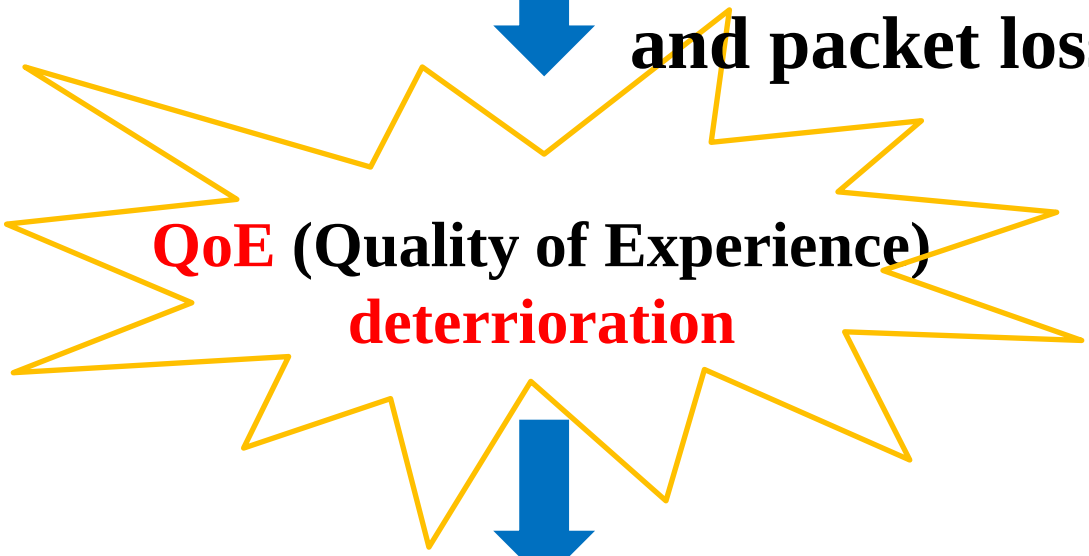
- **Users can operate objects in a 3D virtual space effectively by using haptic interface devices.**

- **Users can precisely perceive the features of each object by touching/holding the object as well as watching it.**

Background (2/2)

When haptic information is transmitted over the Internet, which does not guarantee QoS (Quality of Service)

Network delay, delay jitter and packet loss



- **QoS control**

Previous Work

*1 D.Osada *et al.*, ICCCS, Apr. 2018.

*2 M. Z. Oo *et al.*, ICCCI, June 2021.

We investigate the influence of weight change on human perception of weight in a networked haptic virtual environment by QoE assessment[*1]

Also, we carry out the QoE assessment of softness [*2]

Problem

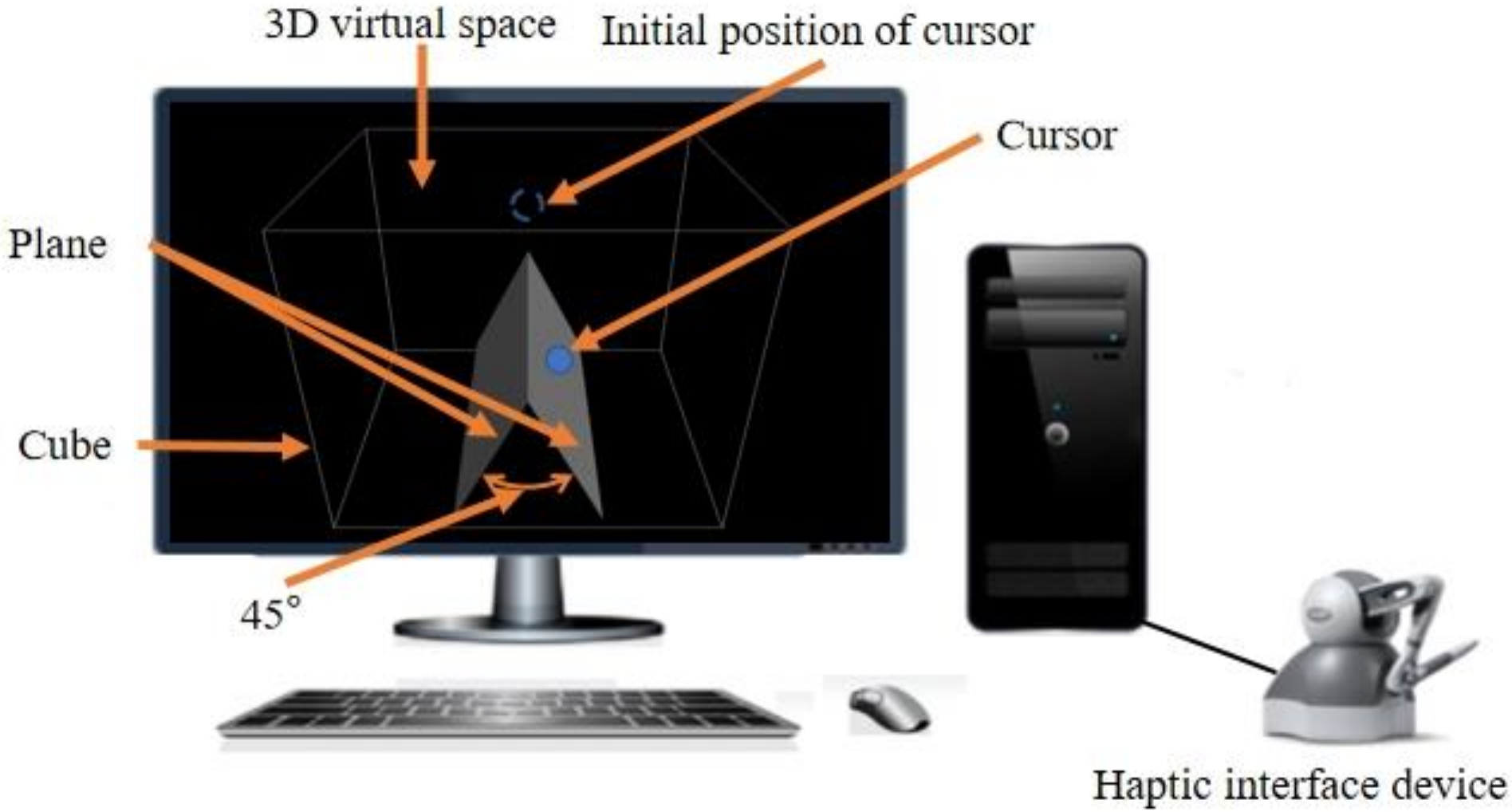
- **The perception has not sufficiently been calrified**

This Work

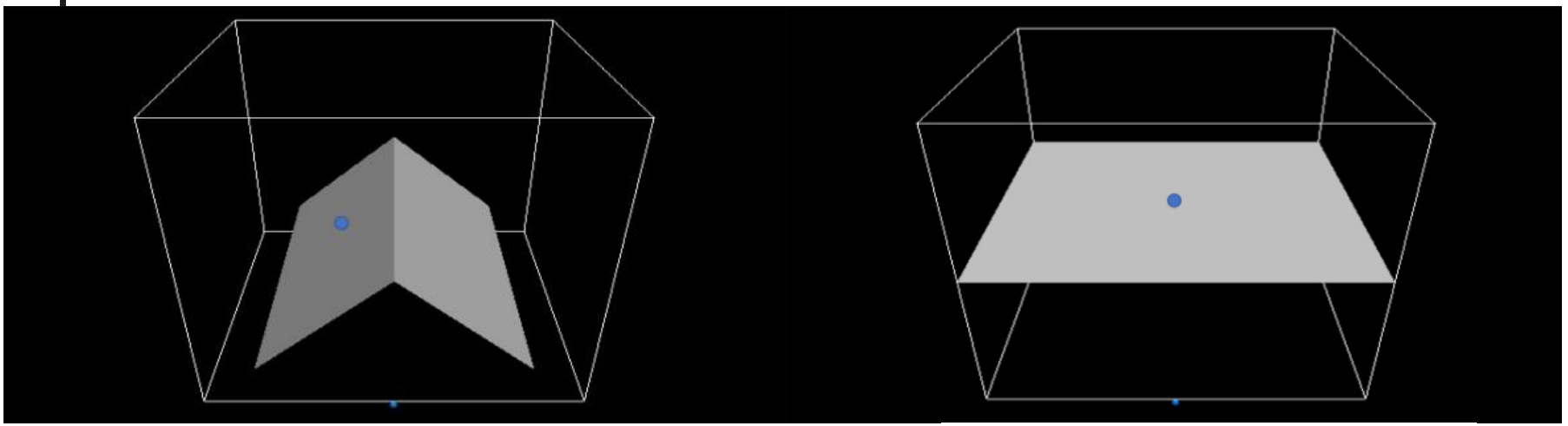
We handle objects including angles, and investigate human perception of shape(especially, angle) with haptics by QoE assessment.

Angle perception system is carried out.

Angle Perception System (1/4)

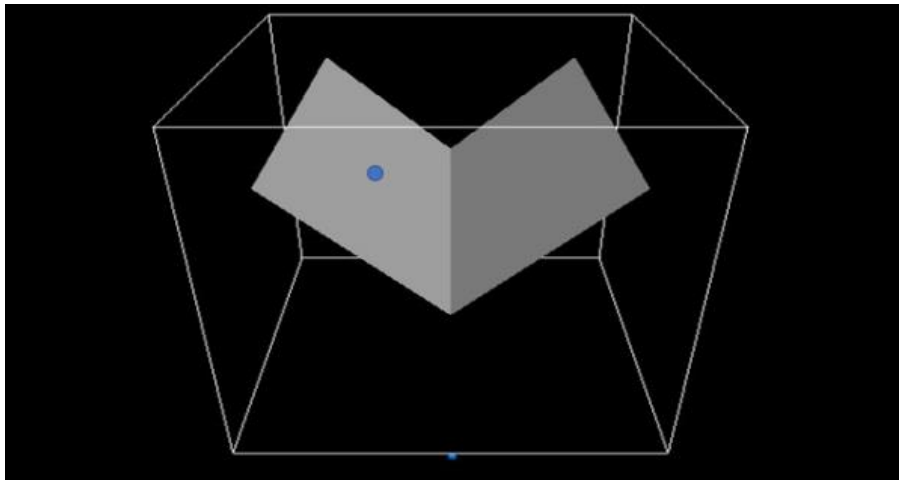


Angle Perception System (2/4)



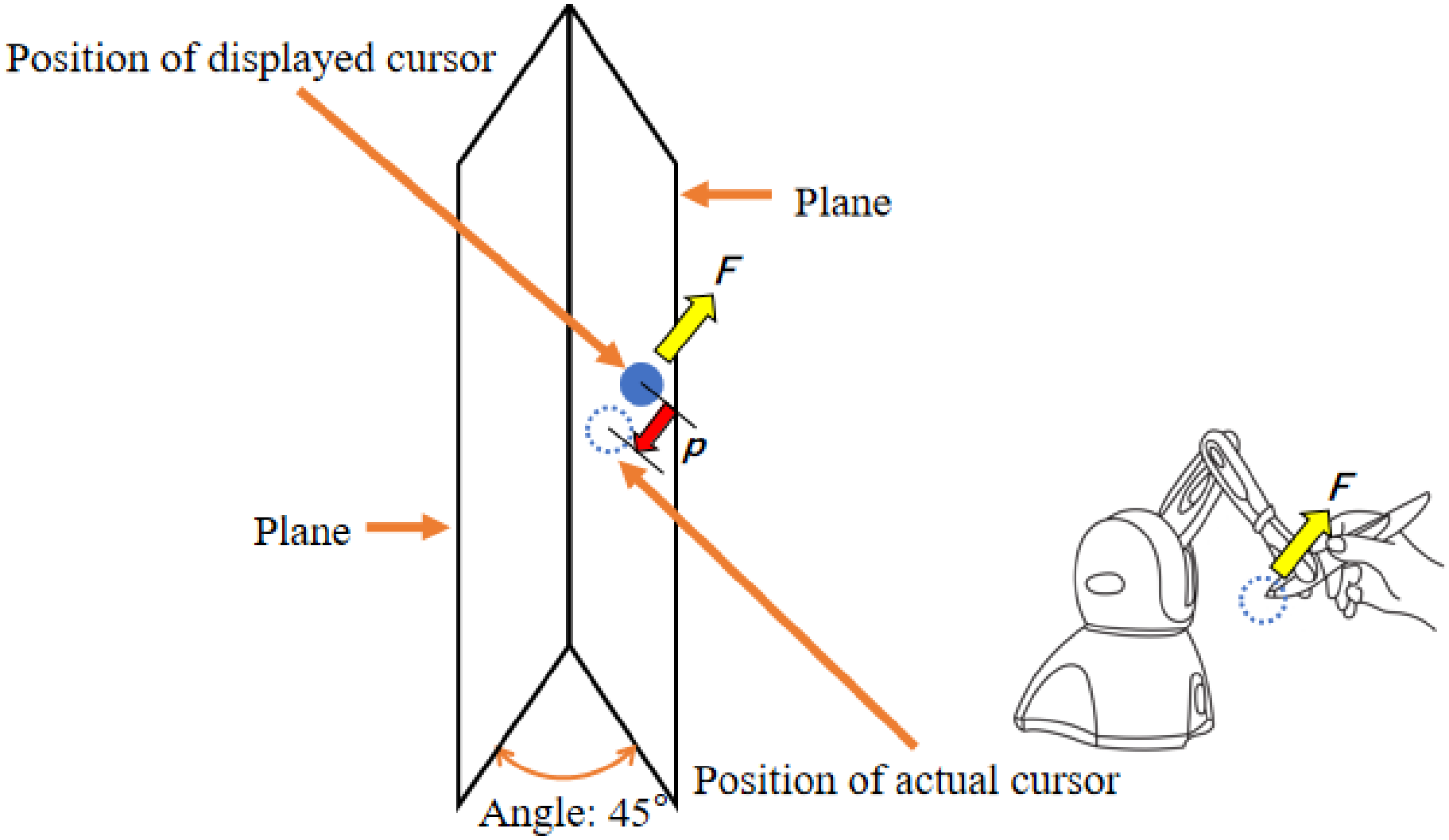
90°

180°



270°

Angle perception System (3/4)



Angle perception System (4/4)

- **The reaction force is calculated by the following equation:**

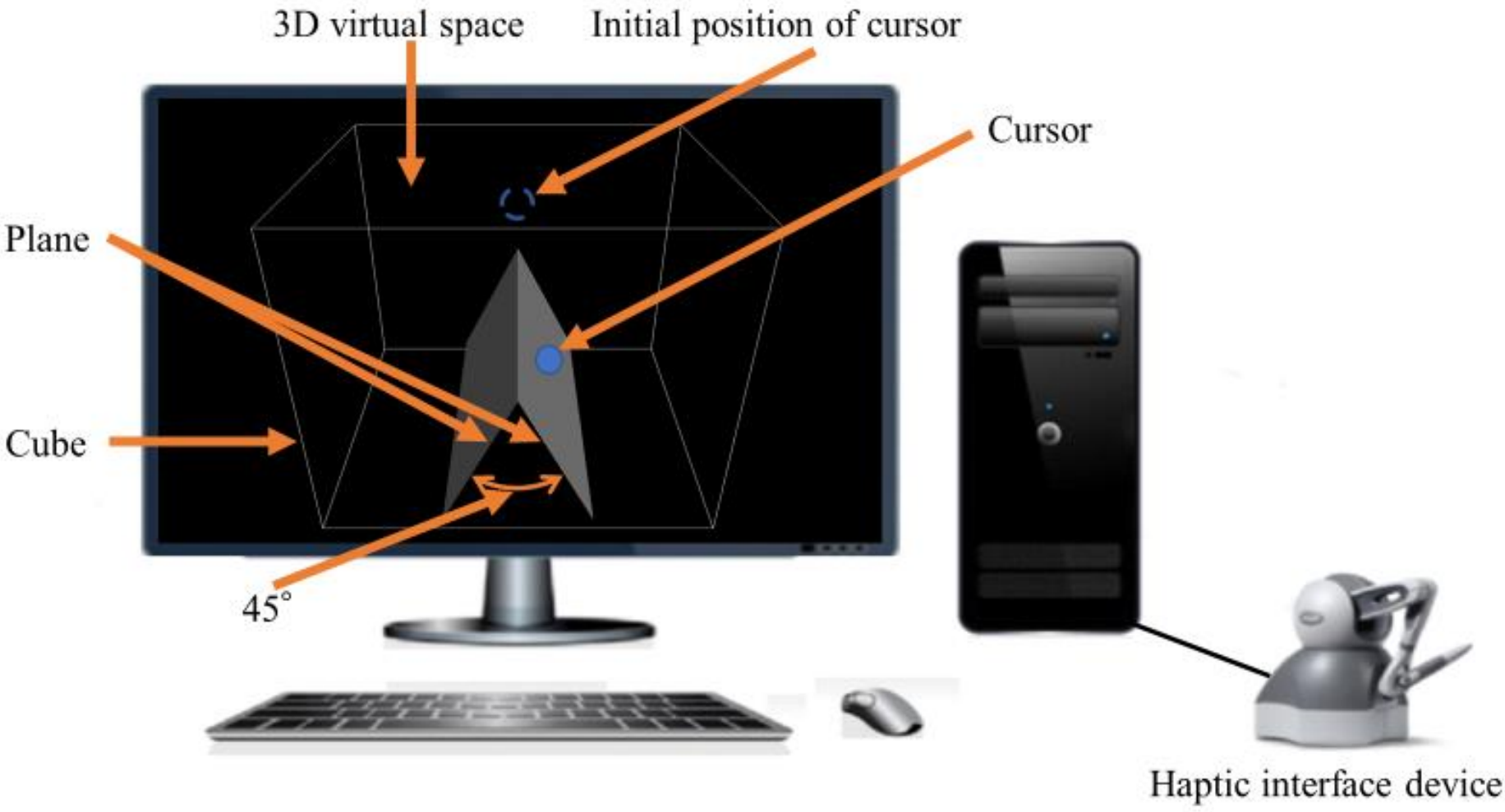
$$\boldsymbol{F} = -K_s \mathbf{p}$$

$\boldsymbol{F}$: **reaction force**
K_s: **spring coeeficient**
p: vector from the center of the displayed cursor on the plane surface to the center of the actual cursor

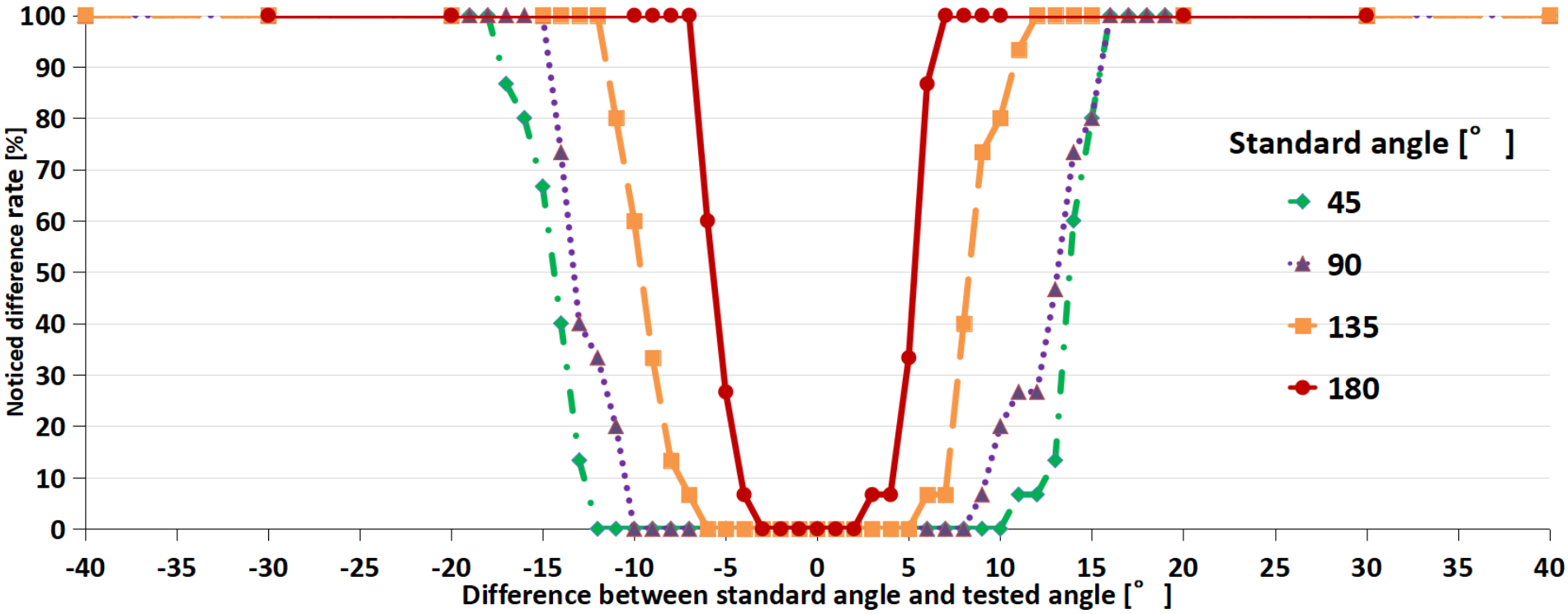
Experiment Method (1/2)

Standard angle [°]	Tested angles [°]	Number of tested angles [°]
15	0, 1, ..., 10, 15, 20, 25, 26, ..., 35	24
30	0, 10, 11, ..., 22, 25, 30, 35, 38, 39, ..., 50, 60	31
45	5, 15, 25, 26, …, 40, 45, 50, 51, …, 65, 75, 85	37
90	50, 60, 70, 71, …, 85, 90, 95, 96, …, 110, 120, 130	37
135	95, 105, 115, 120, 121, …, 150, 155, 165, 175	37
180	150, 160, 170, 171, …, 190, 200, 210	25
225	185, 195, 205, 210, 211, …, 240, 245, 255, 265	37
270	230, 240, 250, 255, 256, …, 285, 290, 300, 310	37
315	275, 285, 295, 296, …, 310, 315, 320, 321, …, 335, 345, 355	37
330	300, 310, 311, ..., 325, 330, 335, 336, ..., 345, 350, 360	31
345	325, 330, 331, ..., 340, 345, 350, 351, ..., 360	24

Experiment Method (2/2)

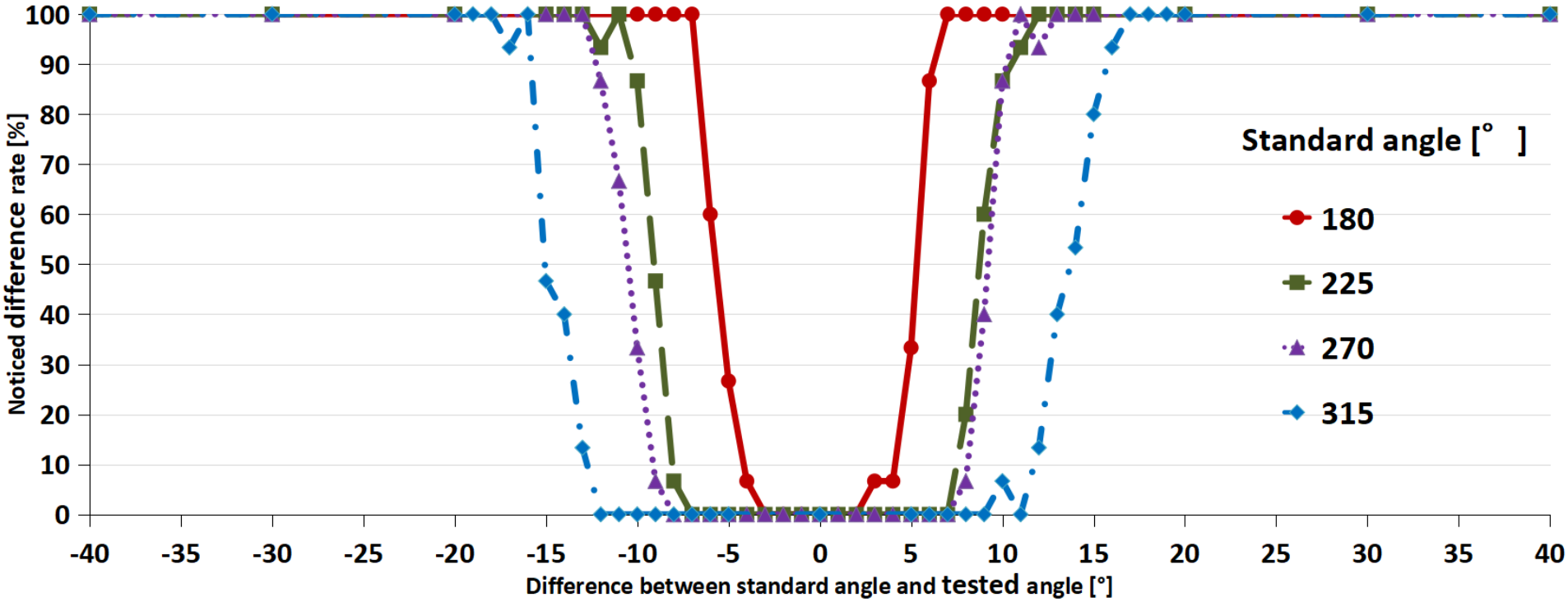


Experimental Results (1/2)



Noticed difference rates for angles from 15° to 180°

Experimental Results (2/2)



Noticed difference rates for angles from 180° to 345°

Conclusion and Future Work

- We clarified the human angle perception for networked haptic virtual environments by QoE assessment.

✓ Linesymmetry properties with respect to a line of the angle difference of 0° when the absolute standard angle is larger

✓ The most sensitive angle degree which human feels is 180°

Future work

- Employ the visual sense as well as the haptic sense and clarify the effect of each sense.
- Other shapes and surface smoothness.