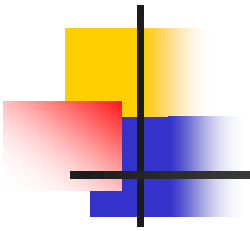
Effects of Haptic and Visual Senses on Angle Perception for Networked Virtual Environments

Yutaka Ishibashi[1], Jianlin Ma[1], and Kostas Psannis[2]

[1]Nagoya Institute of Technology, Japan

[2]University of Macedonia, Greece

IEEE ICCE-TW 2022 July 6-8, 2022



Outline

- **Background**
- **Previous Work**
- **Purpose of This Study**
- **Object Perception System**
- **Experiment Method**
- **Experimental Results**
- **Conclusion and Future Work**

Background

Networked haptic virtual environments

- Users can operate 3D virtual objects 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.

Transmission of haptic information over a network like the Internet

↓ Network delay, delay jitter, and packet loss

QoE (Quality of Experience) deterioration

↓ To solve the problem effectively

QoS control

taking advantage of human perception

Previous Work

Clarification of human perception of various features (e.g., the shape, hardness, and weight of each object)

- **Human angle perception with haptic sense by QoE assessment[*1]**
  - ✓ ***Imperceptible range*: Users hardly perceives the difference in the range.**
  - ✓ ***Allowable range*: The difference is felt to be allowable.**
  - ✓ ***Perceptible range*: Almost all users can perceive the difference.**
- **The ranges can be used under QoS control.[*2]**

Problem

- **Only haptic sense is employed.[*1]**
- **Generally, we use not only haptic sense but also visual sense.**

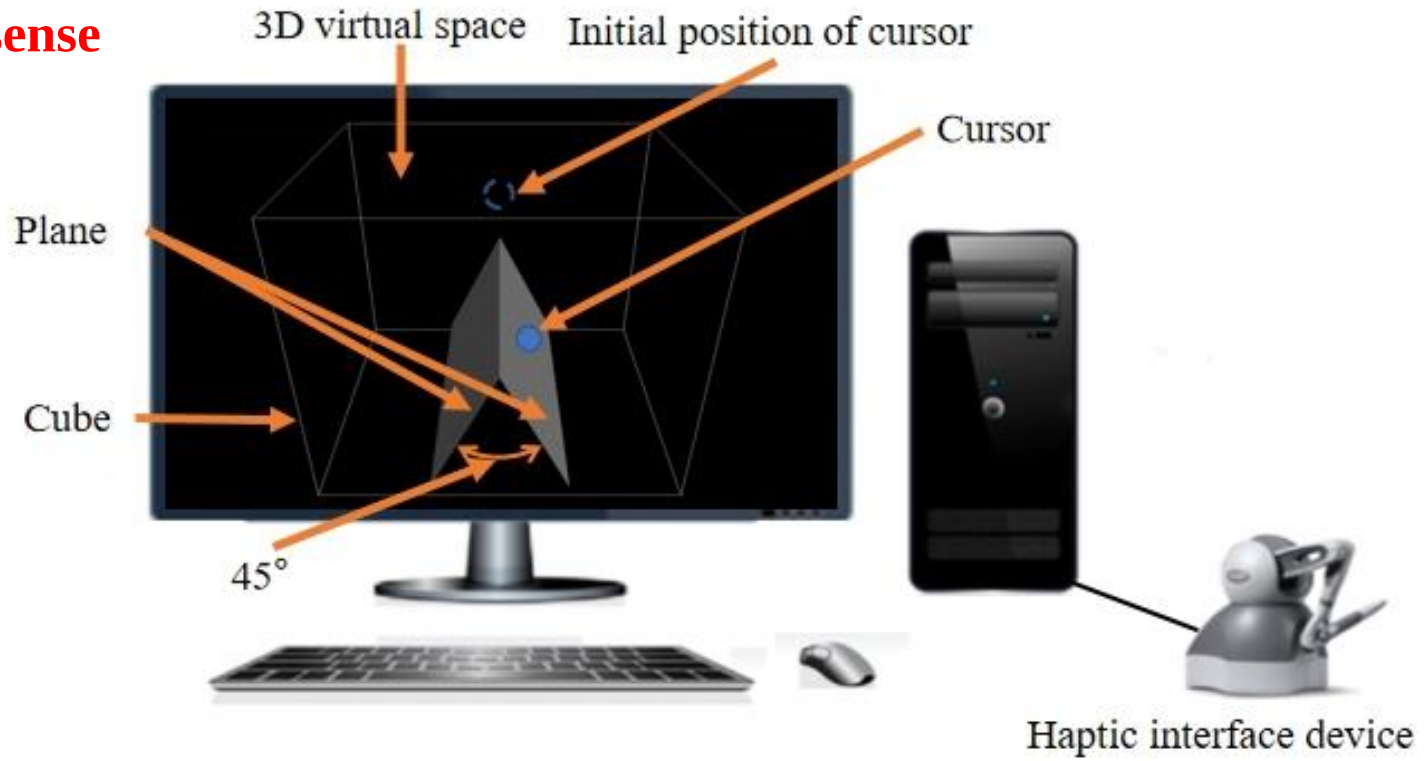
*1 J. Ma *et al.*, CECIT, Dec. 2021.
*2 Y. Ishibashi *et al.*, ACM Multimedia, Oct. 2004.

This Work

Effects of haptic and visual senses on human angle perception

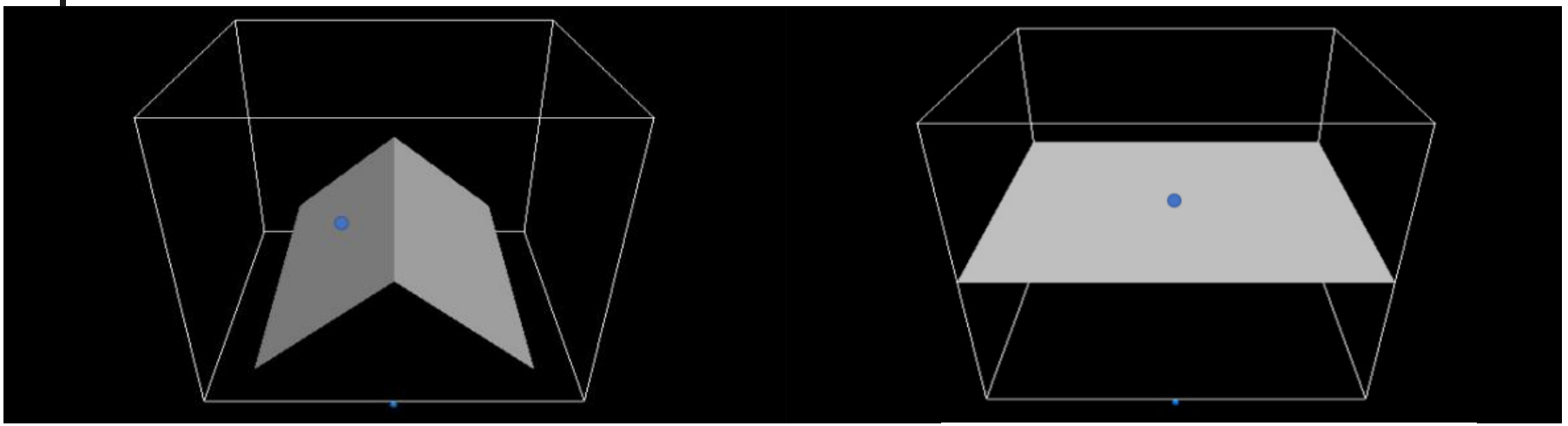
Comparison among three cases by QoE assessment

- ✓ **Only haptic sense**
- ✓ **Only visual sense**
- ✓ **Both senses**



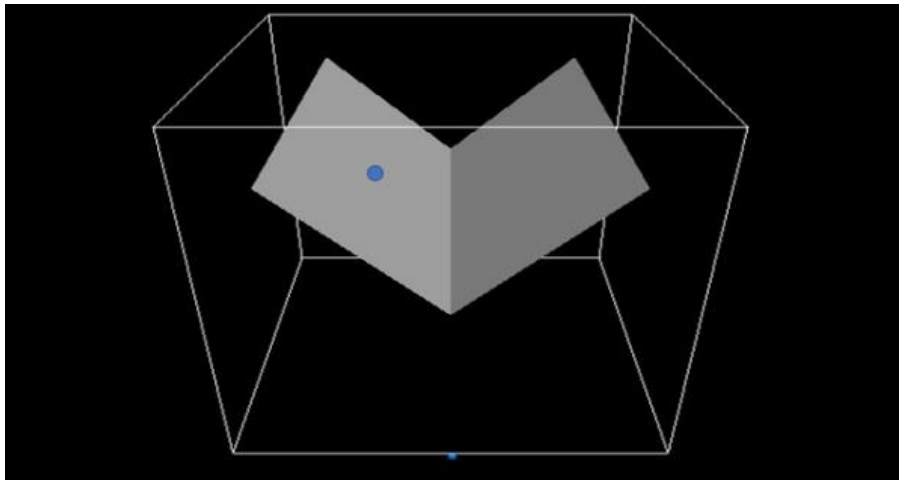
Object perception system

Examples of Angles



90°

180°

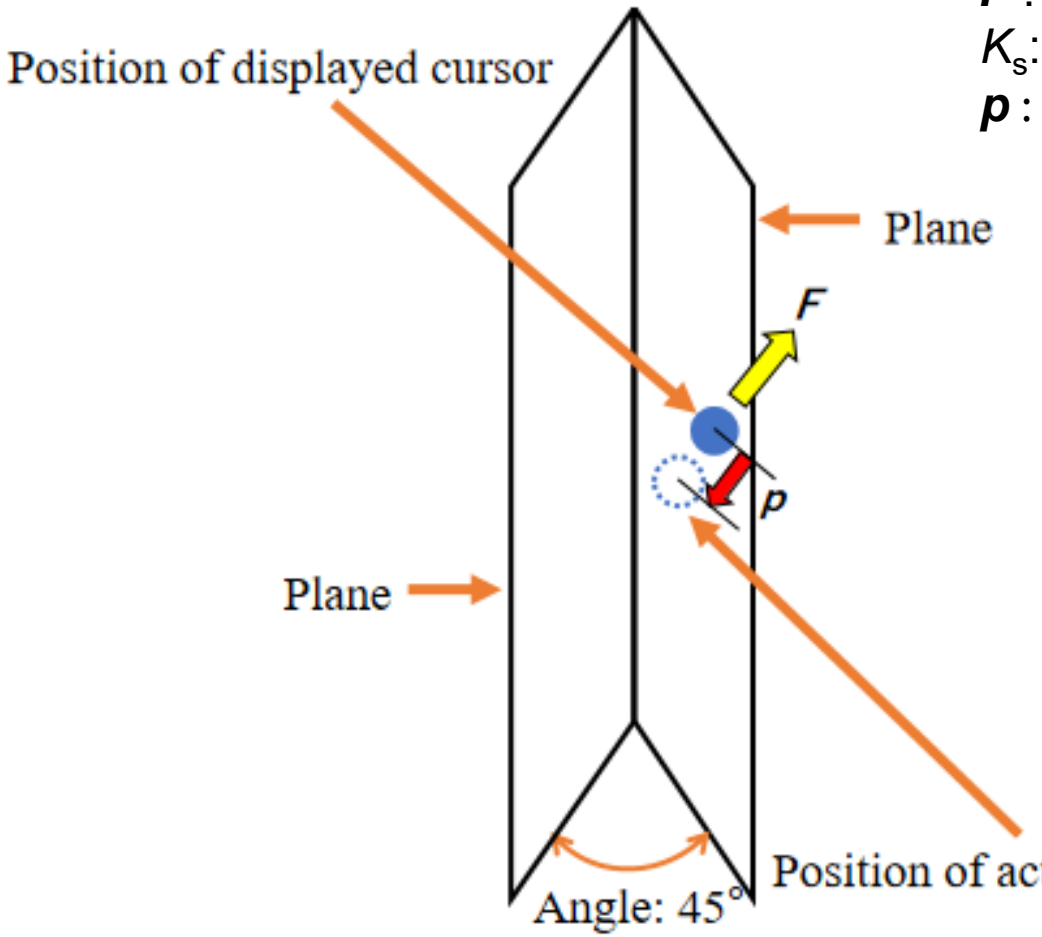


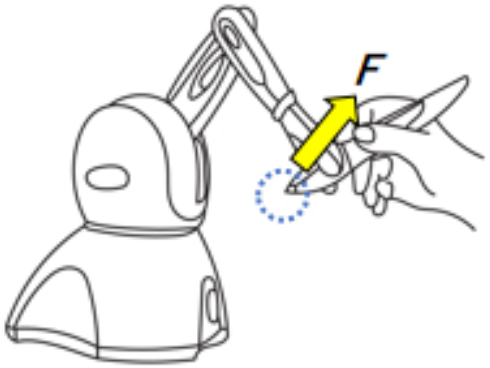
270°

Calculation of Reaction Force

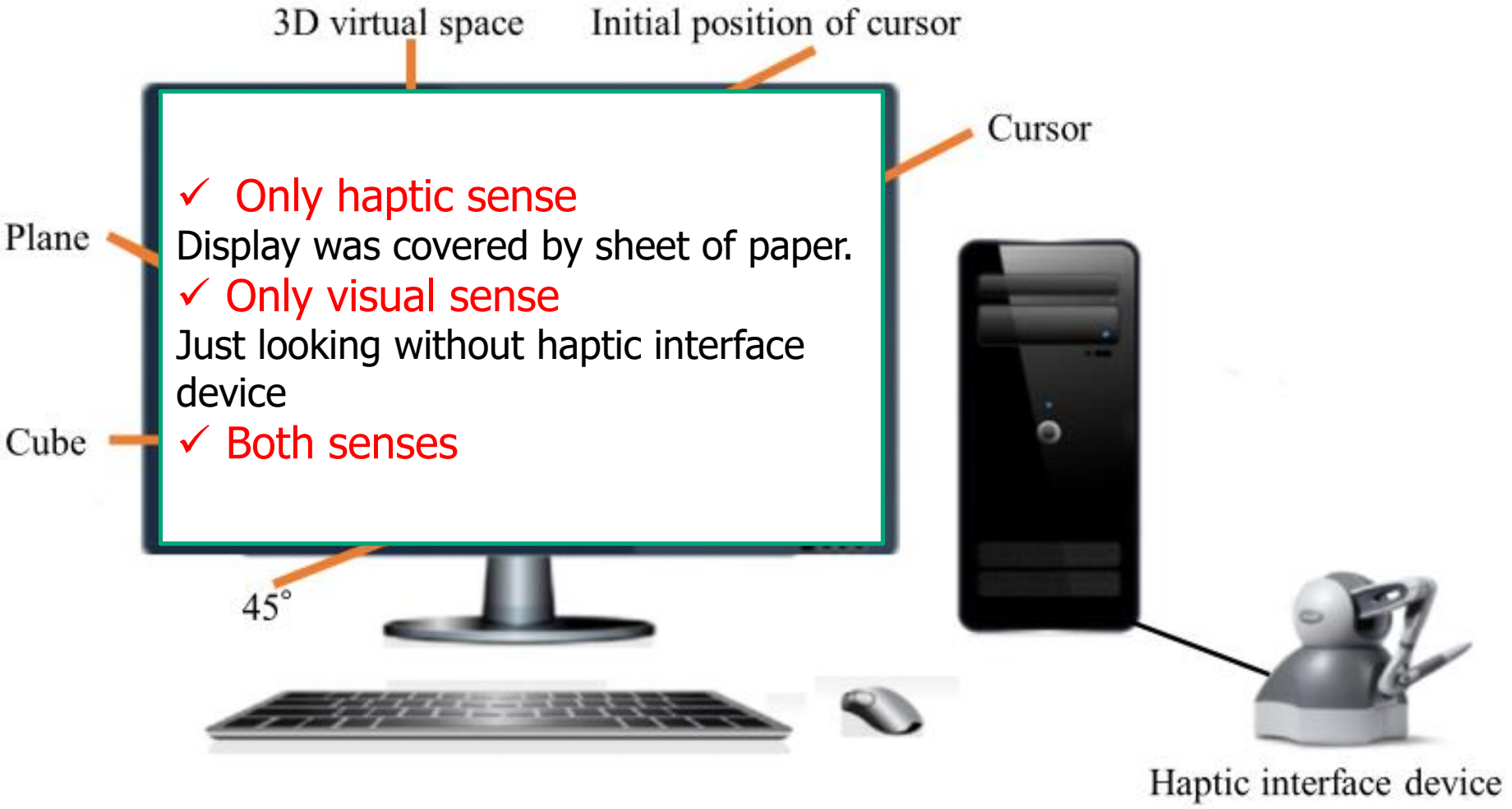
$$\boldsymbol{F} = -K_s\,\boldsymbol{p}$$

F : Reaction force
K_s: Spring (elasticity) coefficient
p : Vector from displayed cursor on plane surface to actual cursor





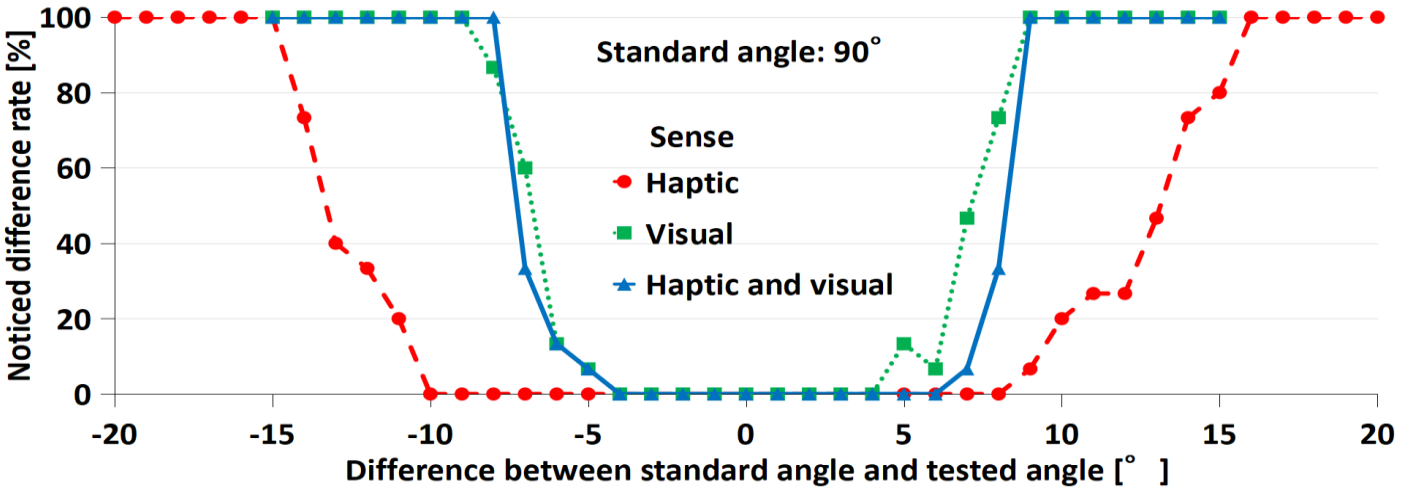
Experiment Method (1/2)

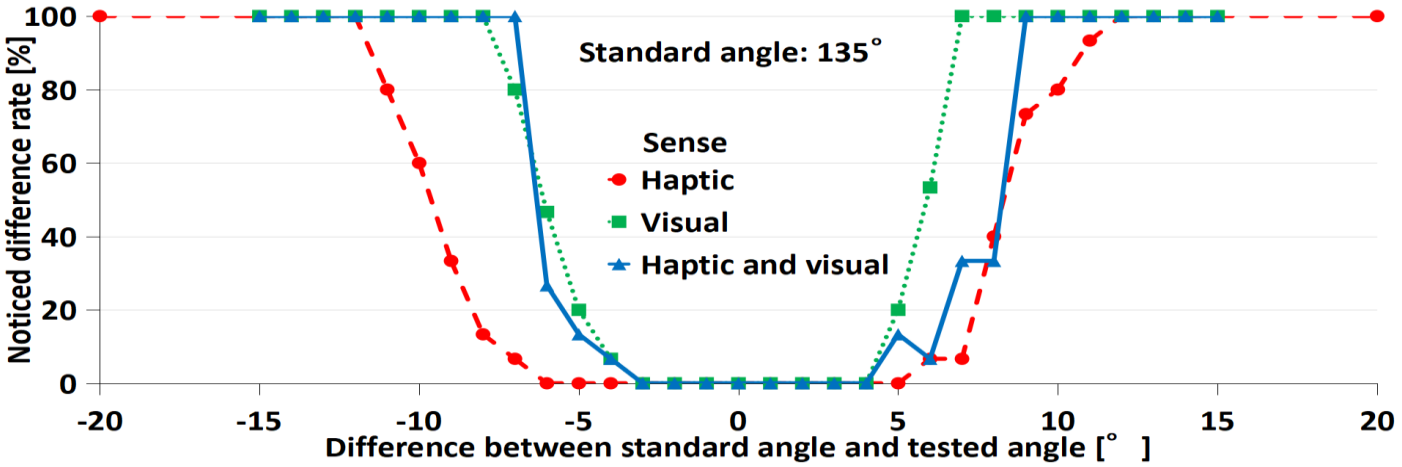


Experiment Method (2/2)

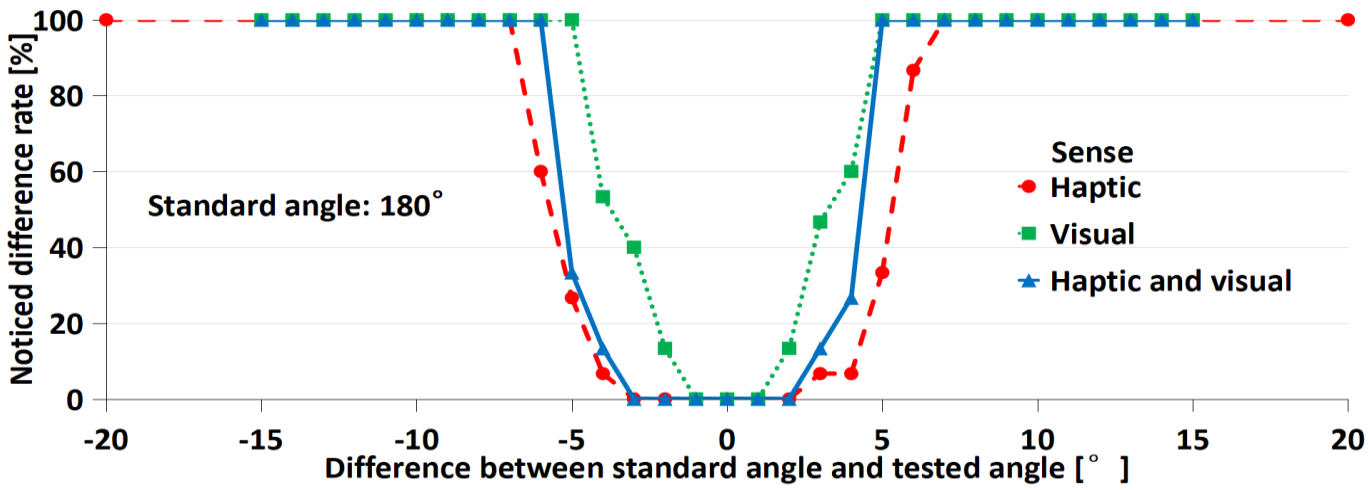
- ✓ **Standard angle [°]**
  changed from 45° to 315° at intervals of 45°
- ✓ **Tested angles [°]** for each standard angle *S*
  changed from *S* − 20° to *S* + 20° at some intervals
- ✓ Presented pairs of standard and tested angles in random order
- ✓ Each subject answered whether the difference between standard and tested angles of the pair was noticeable or not.
- ✓ **Noticed difference rate**
  defined as the ratio of the number of subjects who noticed the difference to the total number of subjects
  (9 men and 6 women) whose ages were from 19 to 27

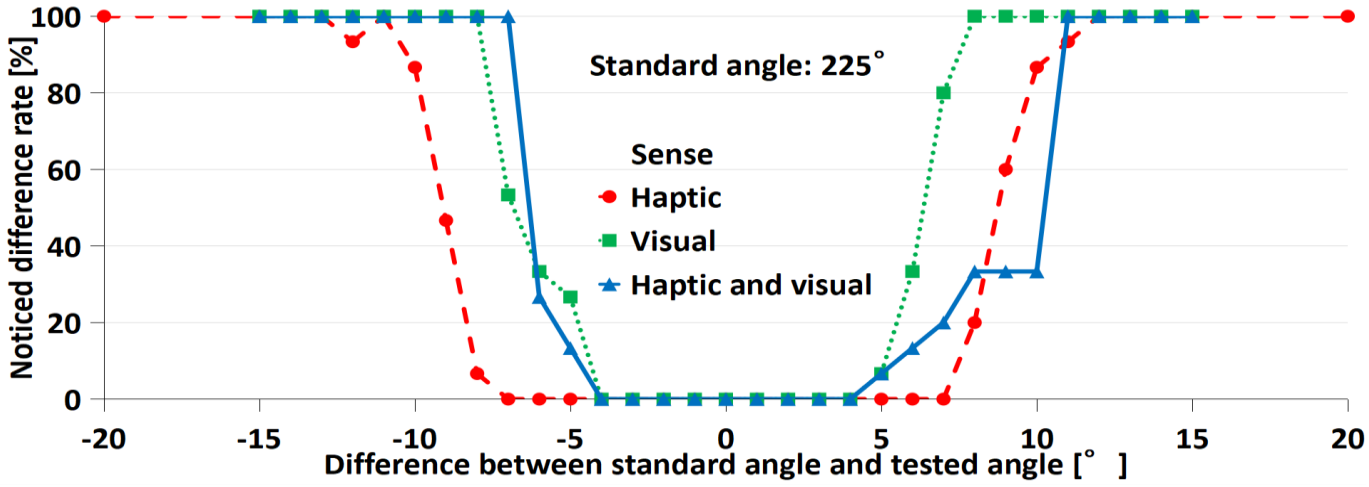
Experimental Results (1/3)



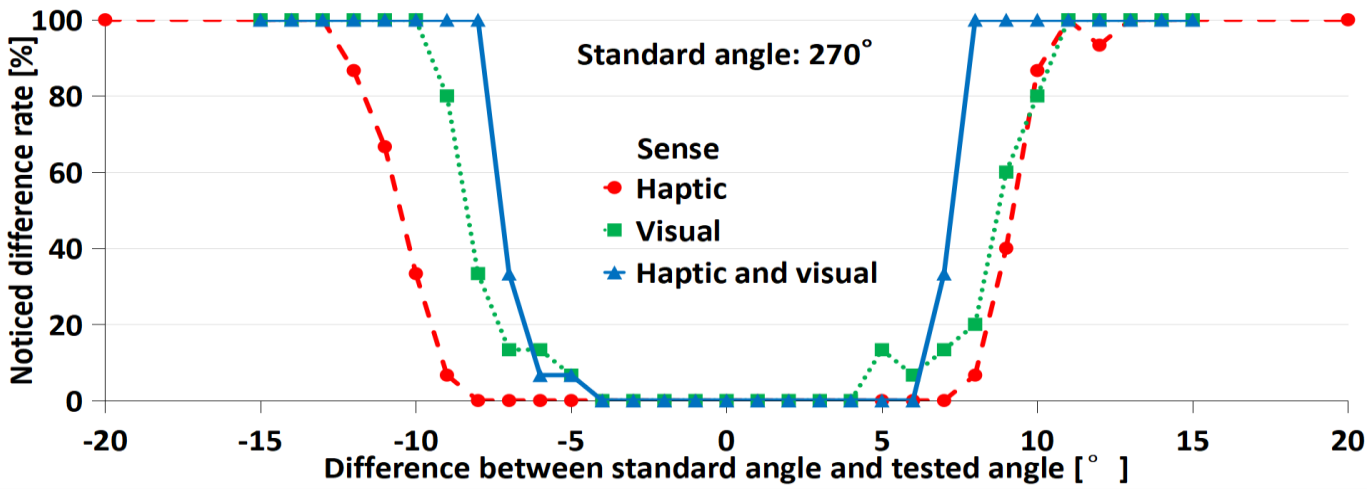


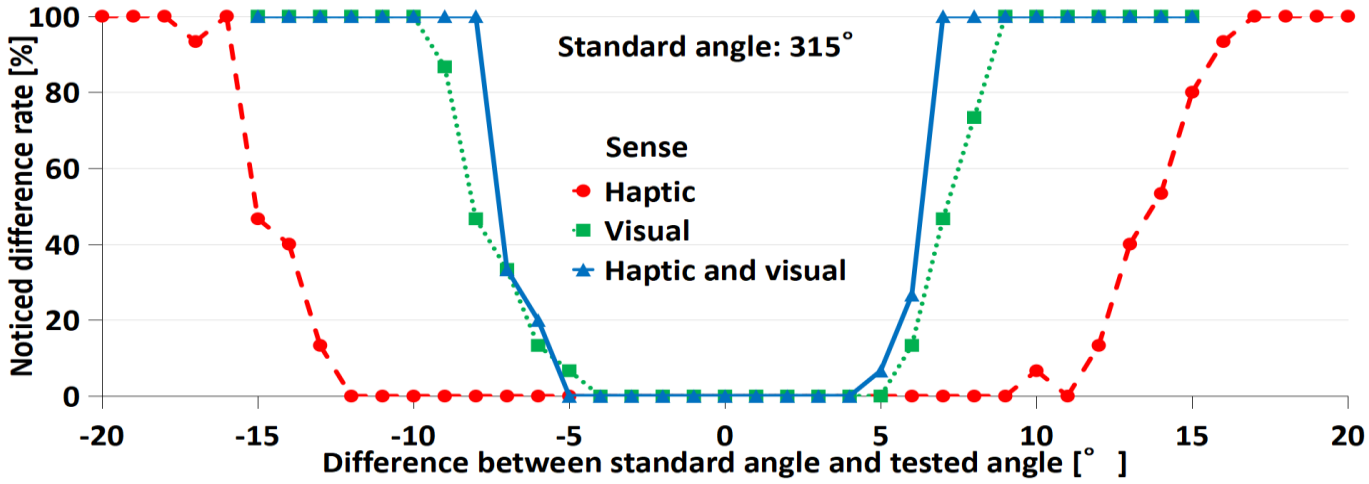
Experimental Results (2/3)





Experimental Results (3/3)





Conclusion and Future Work

We made a comparison of human angle perception among three cases (only haptic, only visual, and both haptic and visual senses) by QoE assessment.

- ✓ **Almost line symmetry properties with respect to a line of the angle difference of 0° when the absolute standard angle is larger**
- ✓ **Visual sense can differentiate angles more easily than haptic sense.**

Future work

- **Handling case in which visually displayed angle degrees are different from haptically displayed ones**
- **Human perception of other features (e.g., other shapes and surface smoothness)**