# Human Perception of Force in Cooperation between Remote Robot Systems with Force Feedback

**Qin Qian[1] Daiki Osada[1] Yutaka Ishibashi[1]**
**Pingguo Huang[2] Yuichiro Tateiwa[1]**

[1]Nagoya Institute of Technology, [2]Seijoh University

Nagoya Institute of Technology

NIT Ishibashi Lab

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# Background (1/2)

- Remote robot systems with force feedback have been actively researched.

  A user remotely controls a robot having force sensors by operating a haptic interface device.

- It is possible for the user to know the shape, weight, and softness of a remote object because he/she can perceive the reaction force from the object through the haptic interface device.

The efficiency and accuracy of work can largely be improved.

# Background (2/2)

When remote operation is performed over the Internet, which does not guarantee the quality of service (QoS)

Network delay, delay jitter and packet loss

QoE (Quality of Experience) degradation

◆ QoS (Quality of Service) control

To carry out QoS control efficiently

Human perception of force (i.e., shape, weight, and softness of a remote object) should be clarified.

*1 D.Osada *et al.*, Proc. IEEE ICCCS, pp. 158-162, Apr.2018.

# Purpose (1/2)

## Previous work

Influences of weight change on human perception of weight by using a haptic interface device in a networked virtual environment were investigated by QoE assessment[*1].

- Humans start to perceive the absolute weight changes heavier than about 20 gf (about 0.2 N).

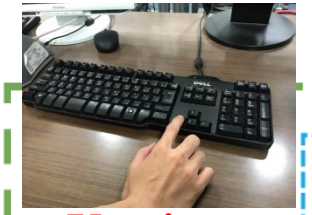
- Investigation of human perception of force in a real environment is necessary.
- Human perception of force has not sufficiently been clarified so far.

# Purpose (2/2)

**This work**

- We carry out QoE assessment on human perception of force in collaborative work between two remote robot systems with force feedback.
- We examine the influence of the length of wooden stick on human perception of force direction.

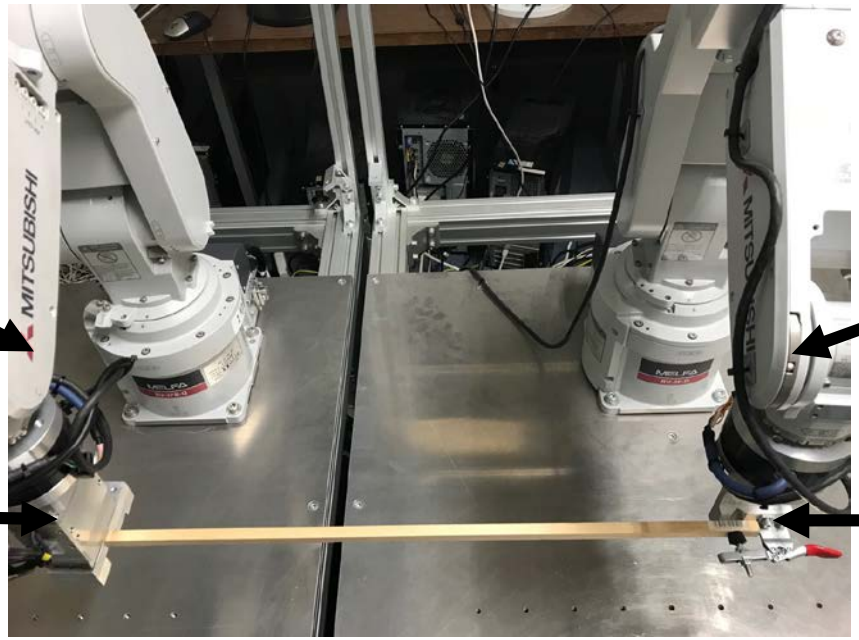
# Two Remote Robot Systems with Force Feedback



# Assessment Method (1/3)

- The two robot arms grasp both ends of a wooden stick (width 10 mm × height 10 mm × lengths 300 mm and 600 mm) with the toggle clamp hand and the electric hand.

Subject side:
robot arm 2




User side:
robot arm 1

Electric hand

Toggle clamp hand

# Assessment Method (2/3)

**User side:**

- The user moved only one side (robot arm 1) of the wooden stick in one direction of front and back, left and right, and up and down with key input.
- Distances to move

| Length \ Direction | front-back | left-right | up-down |
|---|---|---|---|
| **300 mm** | | 0.01 mm ~ 0.16 mm | |
| **600 mm** | 0.06 mm ~ 0.48 mm | 0.01 mm ~ 0.16 mm | 0.06 mm ~ 0.66 mm |

- The moving distance and moving direction were selected in random order per subject.

# Assessment Method (3/3)

**Subject side:**

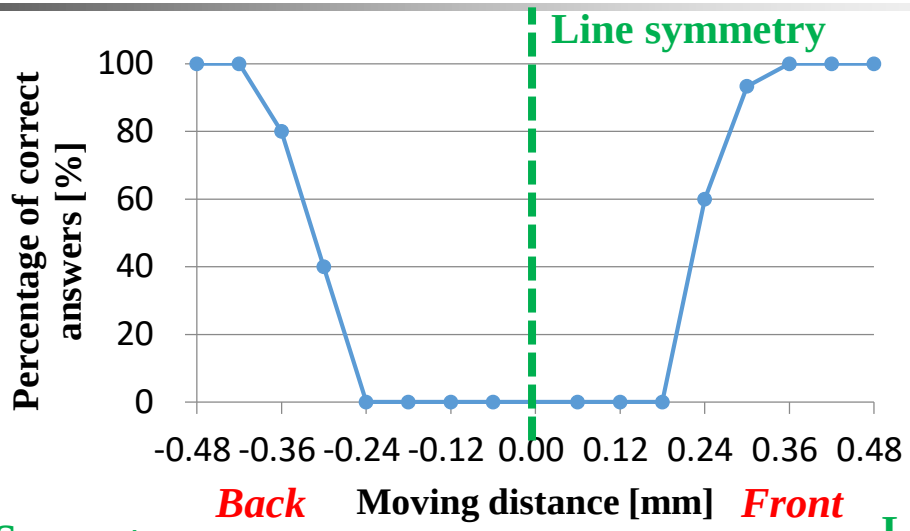
- Each subject just held the stylus of the haptic interface device and pressed the button as shown on the right figure.

- Each subject was asked to select one answer from among the following three answers:

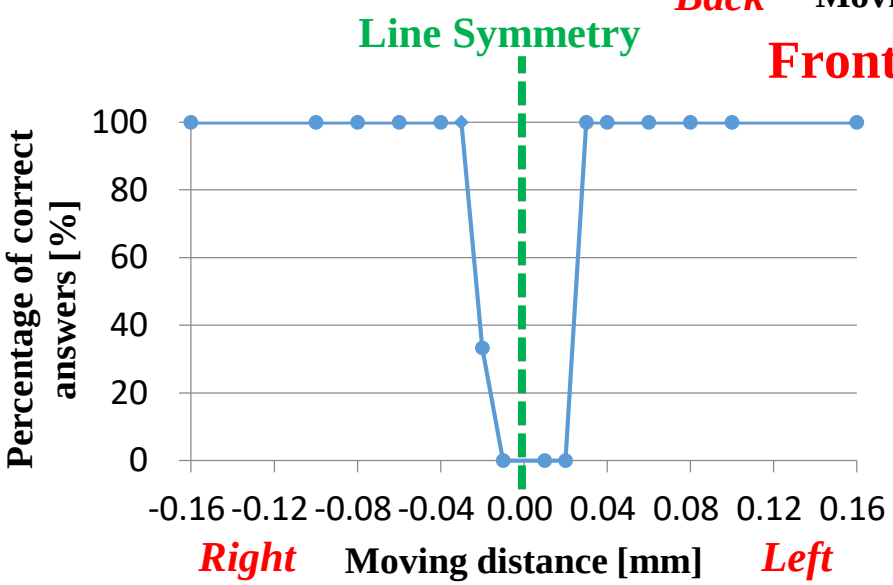
1. "I can perceive the force and know the moving direction" (he/she was asked to say the moving direction)
2. "I can perceive the force but do not know the moving direction"
3. "I cannot perceive any force"

- We calculated the percentage of correct answers(i.e., the force was perceived and the correct moving direction was answered).

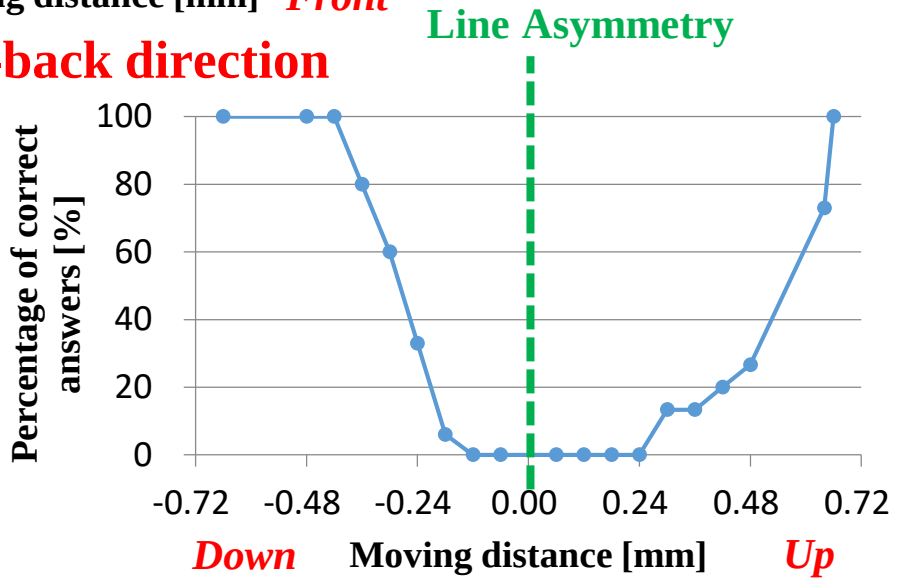
# Assessment Results (1/4)




Front-back direction

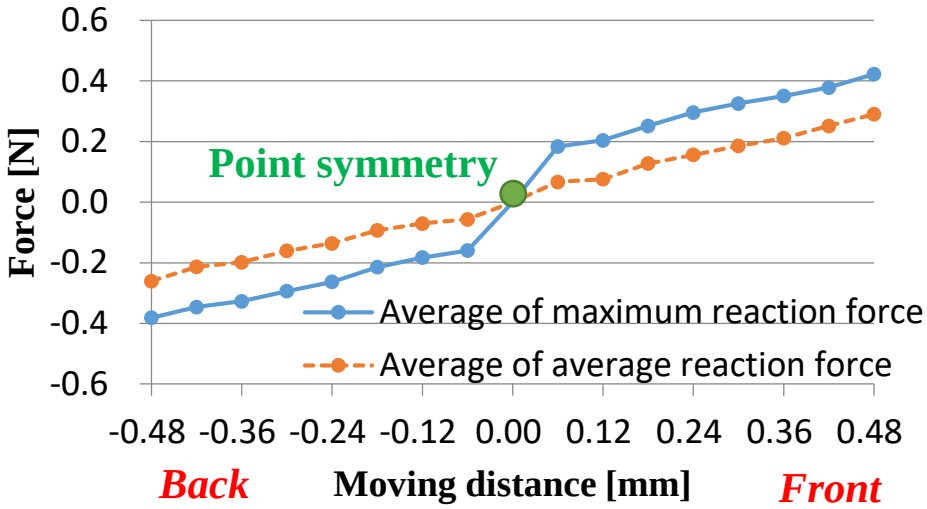



Left-right direction

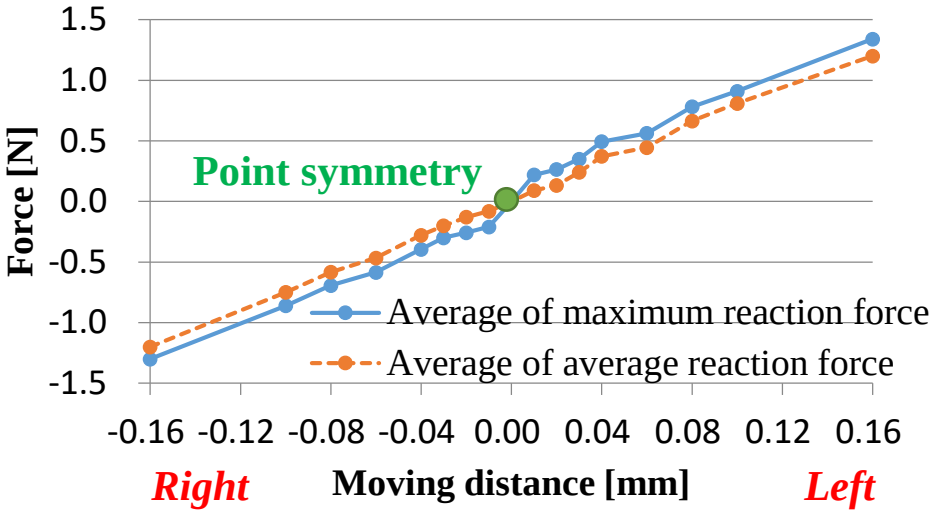



Up-down direction

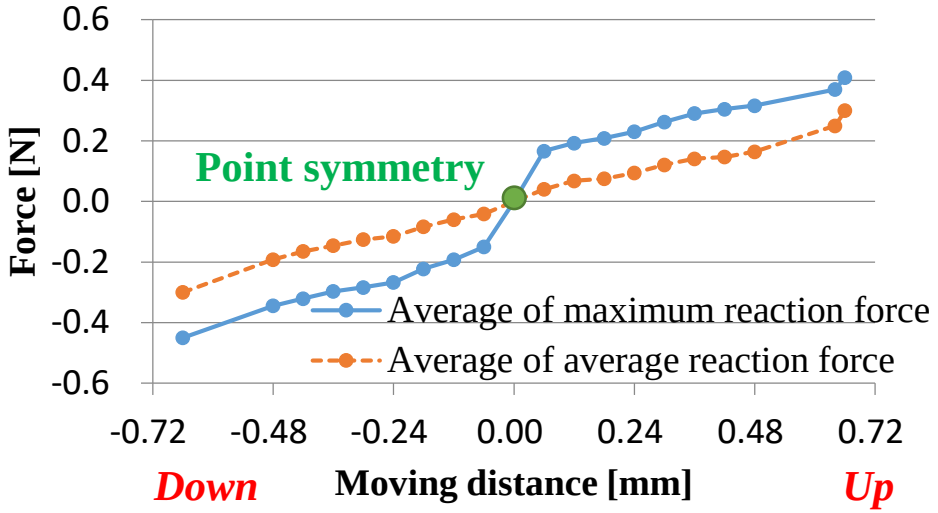
# Assessment Results (2/4)




**Front-back direction**

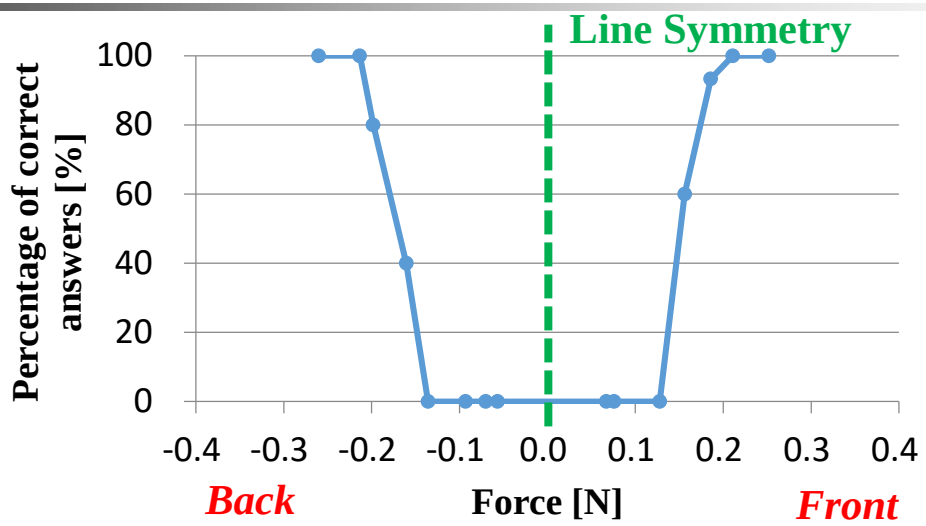



**Left-right direction**

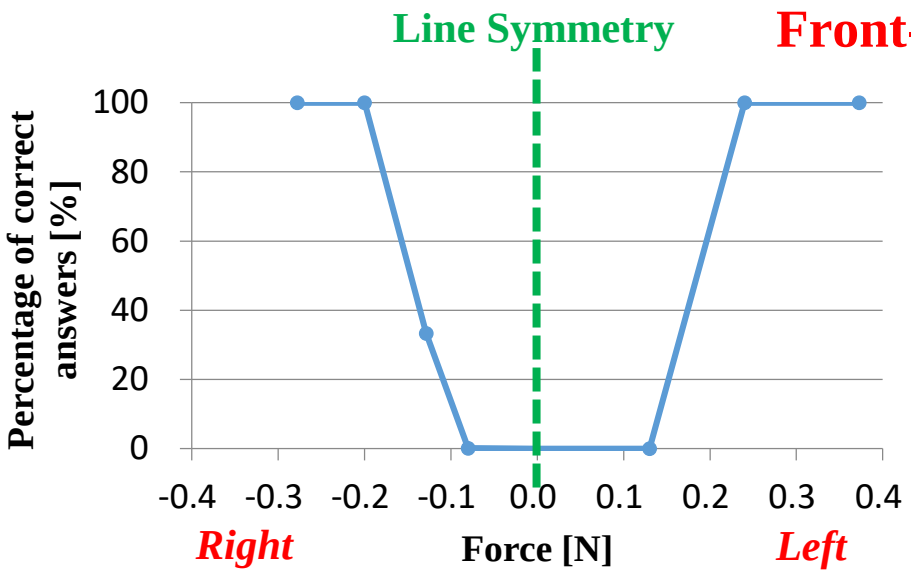



**Up-down direction**

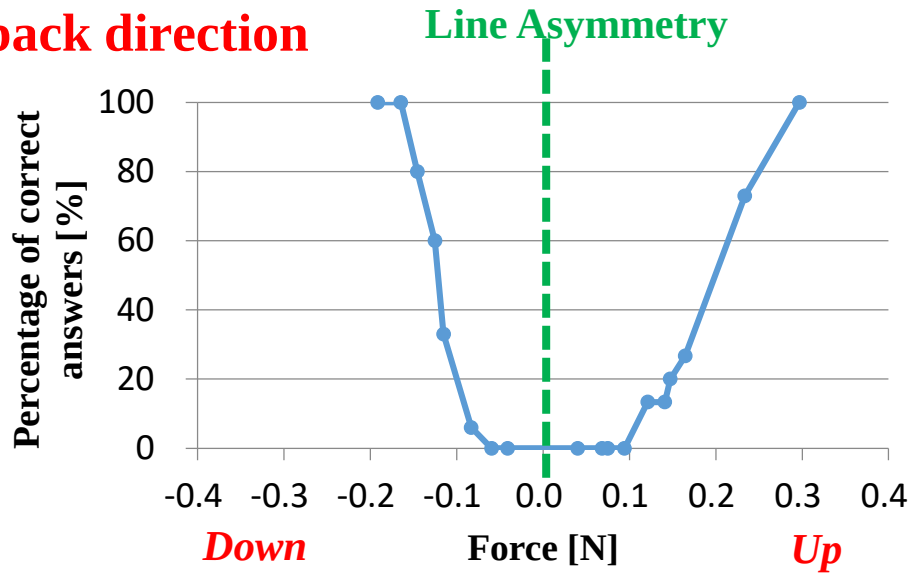
# Assessment Results (3/4)




**Front-back direction**

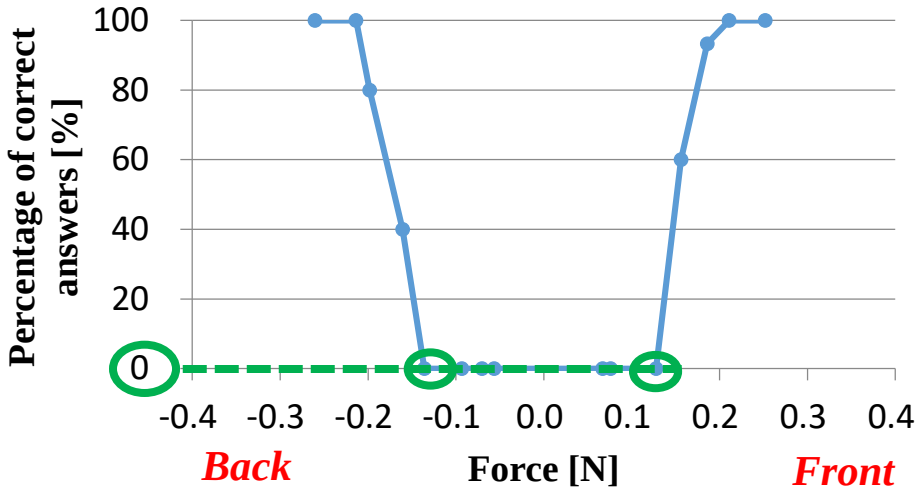



**Left-right direction**

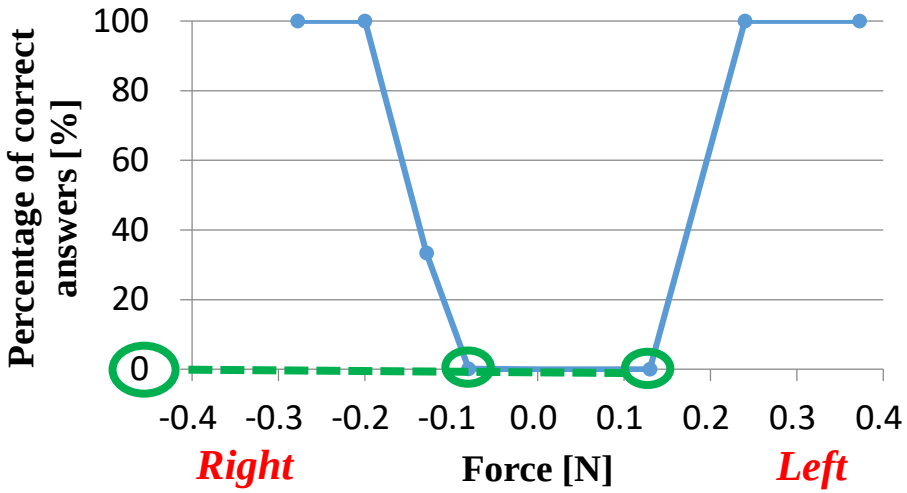



**Up-down direction**

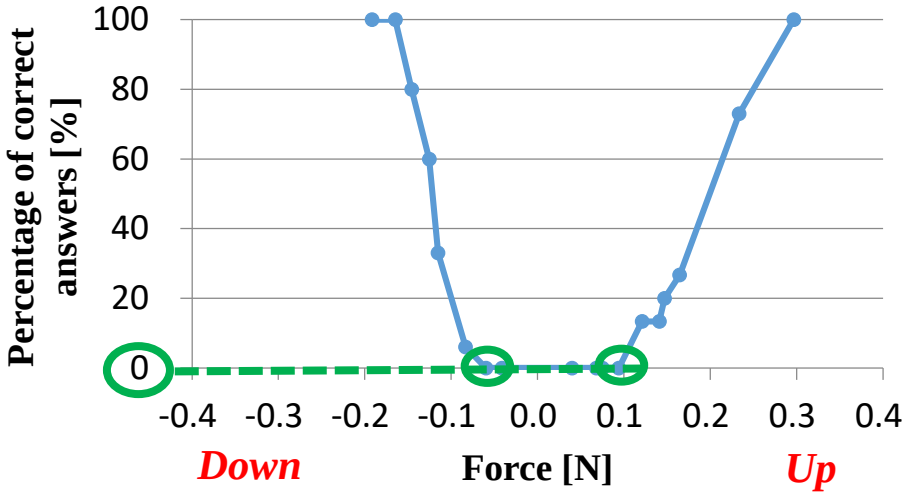
# Assessment Results (3/4)




**Front-back direction**

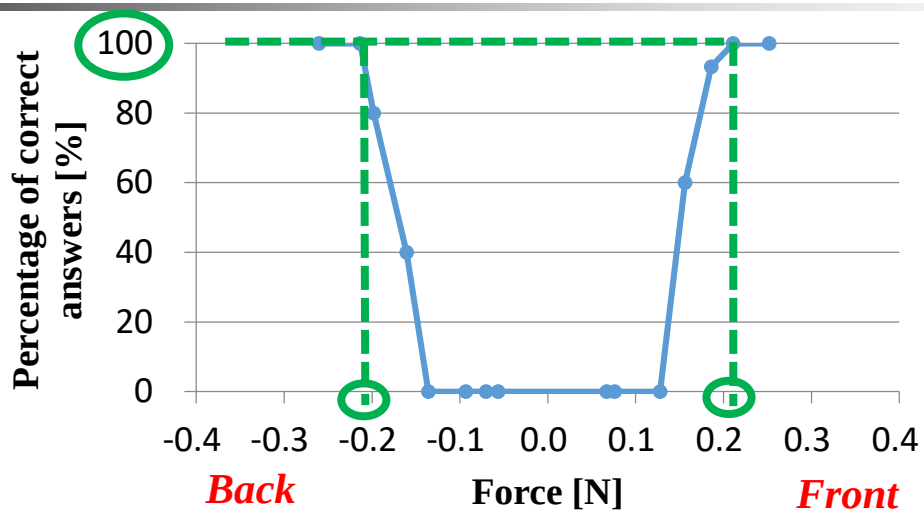



**Left-right direction**

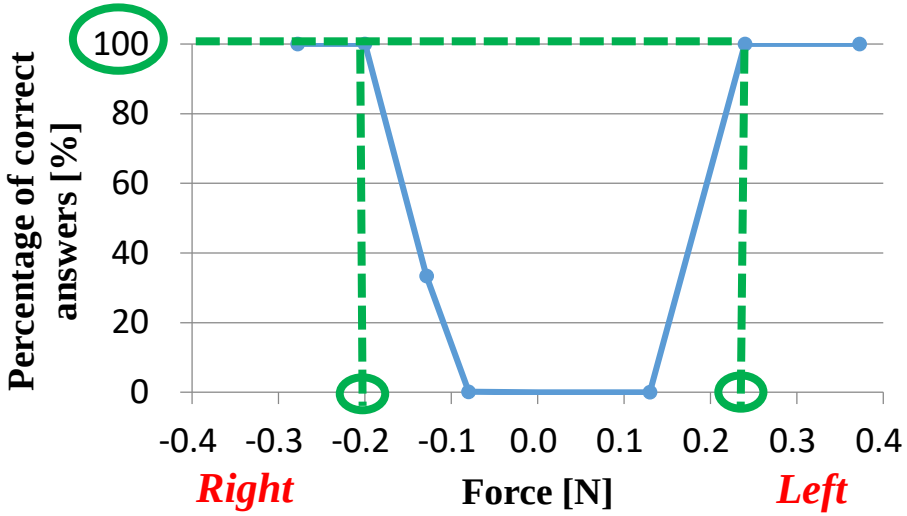



**Up-down direction**

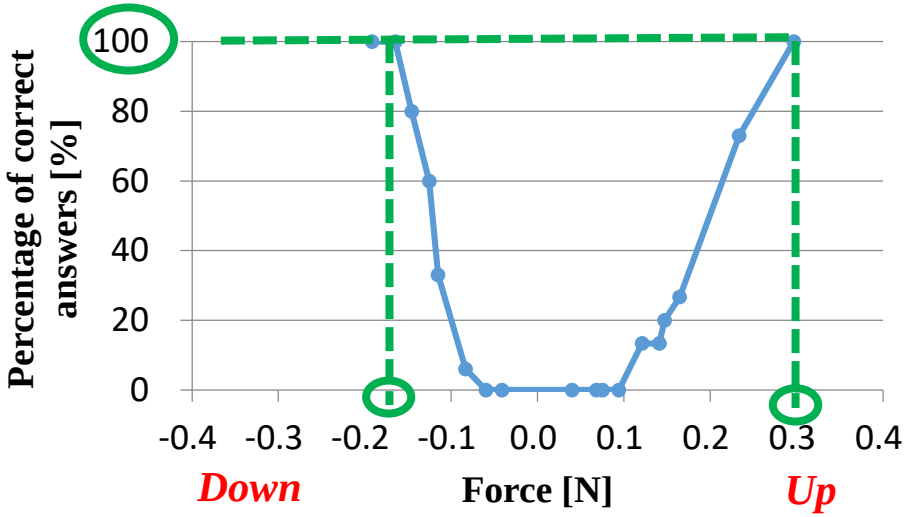
# Assessment Results (3/4)




**Front-back direction**

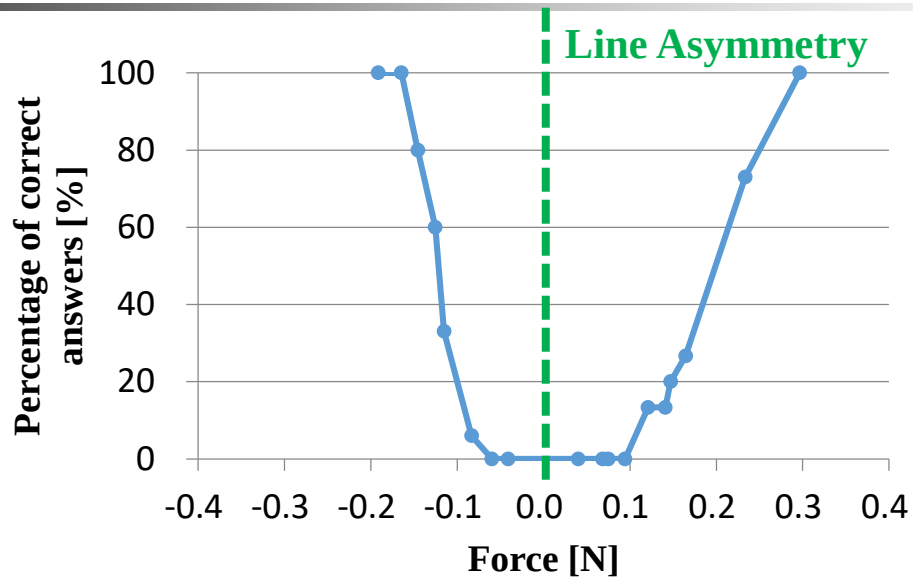



**Left-right direction**




**Up-down direction**

# Assessment Results (4/4)




**Up-down direction**

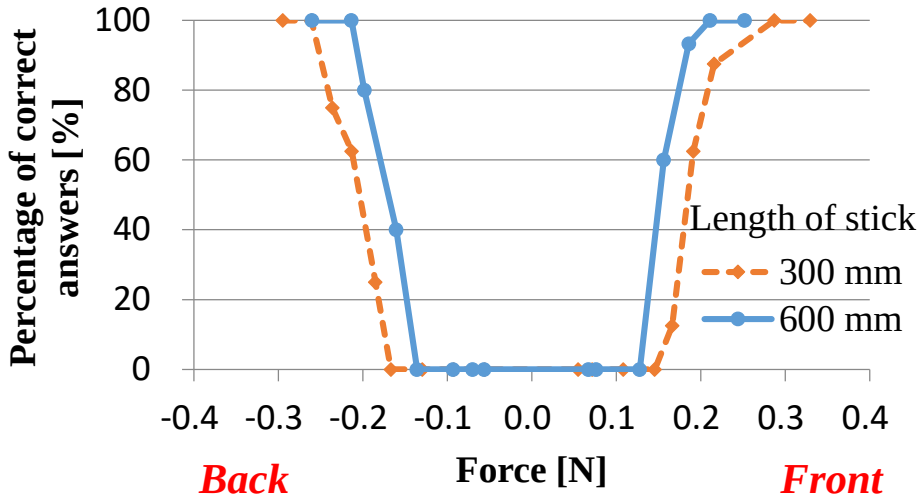
The Gravity is applied to the haptic interface device.

To hold the device

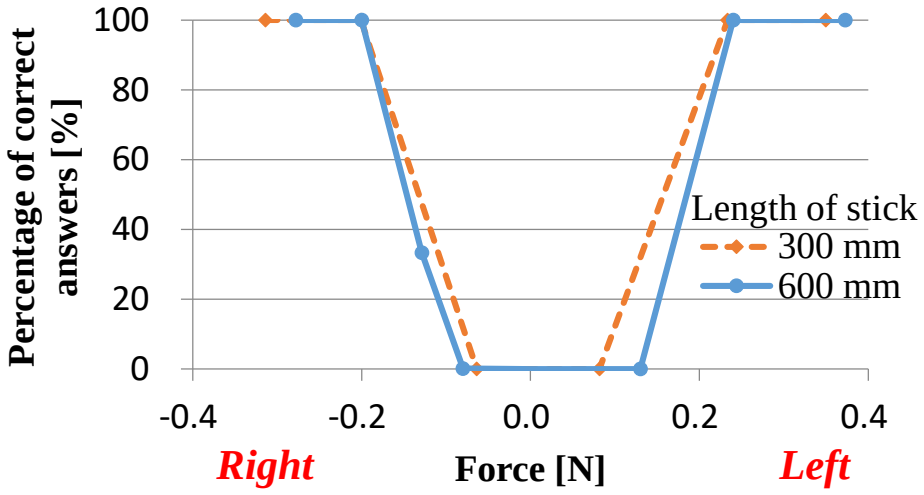
Force perception in the up direction is harder than other directions.

*2 D.Osada *et al.*, IEICE Technical Report, CQ2018-31, July 2018.

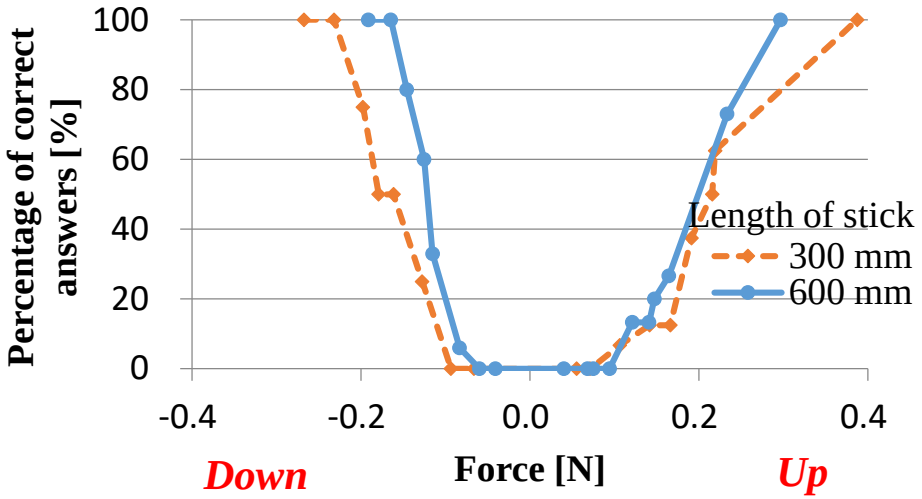
# Influences of Length of Stick




**Front-back direction**




**Left-right direction**




**Up-down direction**

# Conclusion

- We carried out QoE assessment to investigate to what extent humans can accurately perceive the force direction by using a haptic interface device in the remote robot system with haptics.
- We investigated the influence of the length of wooden stick on the human perception of the force direction.

- Humans can perceive the force correctly as the force is equal or greater than about 0.2 N excluding the up direction.
  (This is almost the same as result that humans start to perceive the absolute weight changes heavier than about 20 gf [*1])
- The human perception of the force hardly depends on the length of the wooden stick.

# Future Work

- Assessment of force perception by using grasped sticks with various length or softness
- Study on QoS control by using human perception of force