# Assessment of Weight Perception with Haptics in Networked Virtual Environment

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# Outline

- Background
- Purpose
- Weight Balance System
- Assessment Method
- Assessment Results
- Conclusion and Future Work

# Background [1/2]

Research on collaborative work using haptic interface devices has actively been conducted.

By using the devices, a user can feel the shape, softness and weight of an object in a networked virtual environment.

It is expected that the efficiency of collaborative work can greatly be improved.

# Background [2/2]

Information regarding haptics is transferred over a network in which the quality of service (QoS) is not guaranteed.

Network delay, delay jitter, and packet loss

The quality of experience (QoE) may seriously deteriorate.

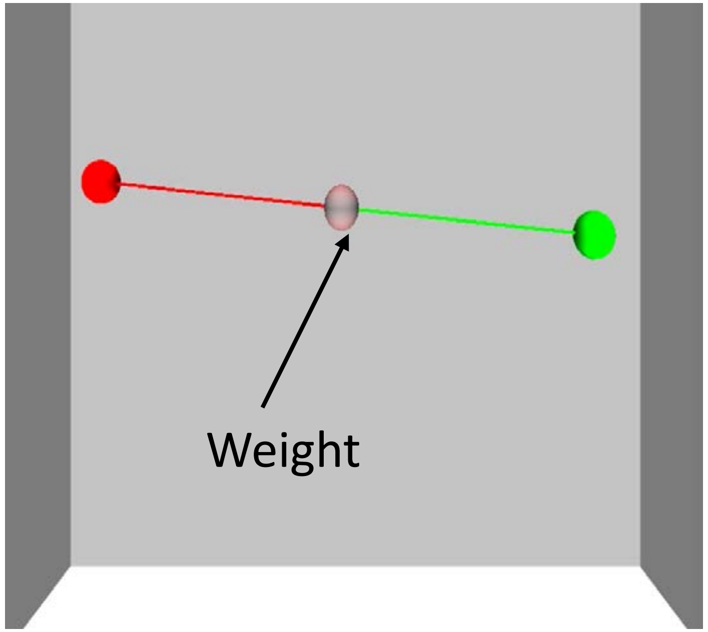
Need to investigate how much largely QoE about haptics deteriorates.

# Purpose [1/4]

*1 Osada *et al*., in Record of 2017 Tokai-Section Joint Conference on Electrical, Electronics, Information, and Related Engineering, Sep. 2017.

**Previous work**

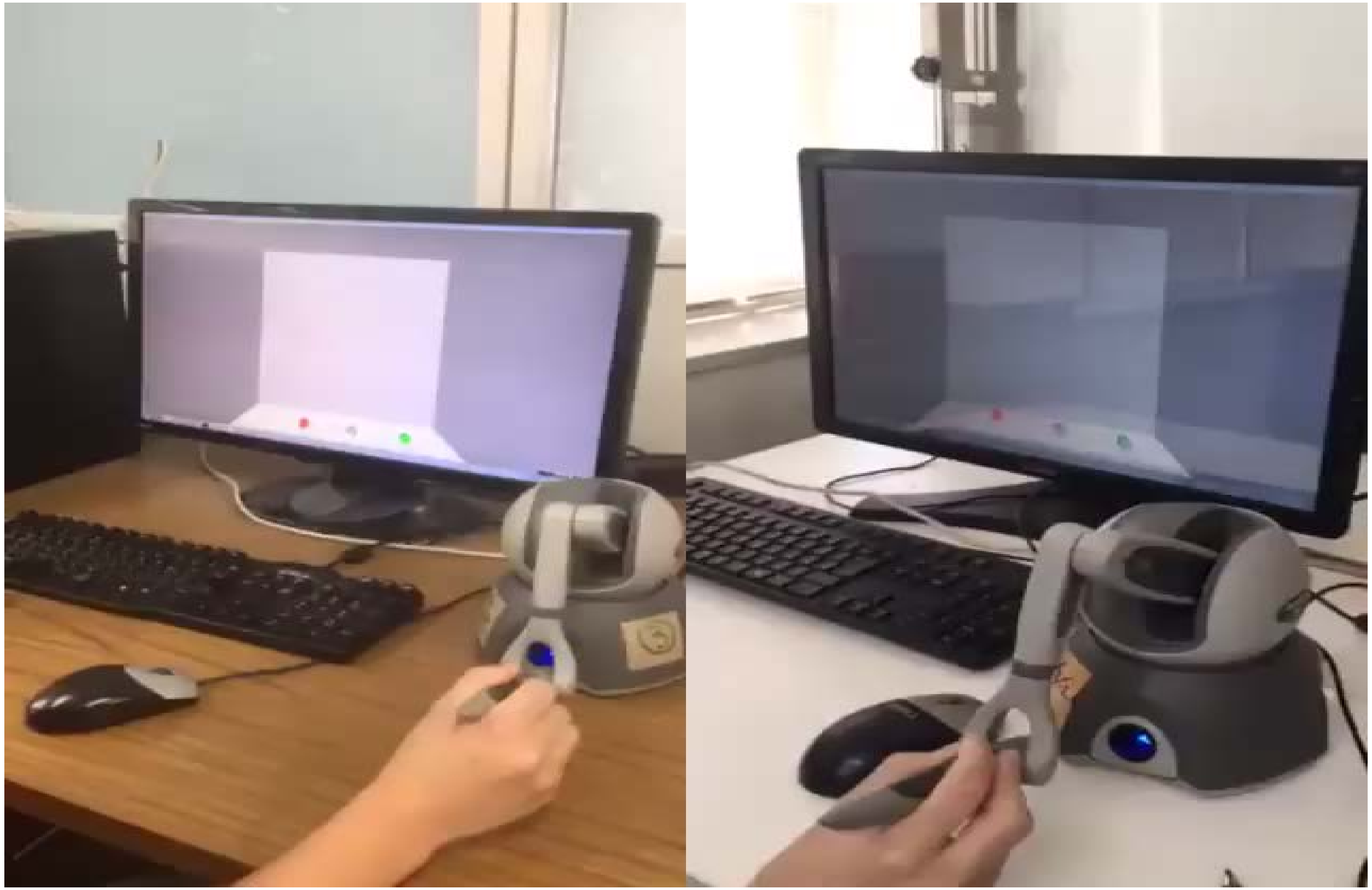
Investigate how largely the network delay affects human perception of weight for a system in which two users lift a virtual weight collaboratively (Weight Balance System).*1




Displayed image of 3D virtual space

- As the network delay increases, the work becomes more difficult.
- If the network delay is less than about 50 ms, the work can be performed smoothly by perceiving only weight.

# Demo video of work



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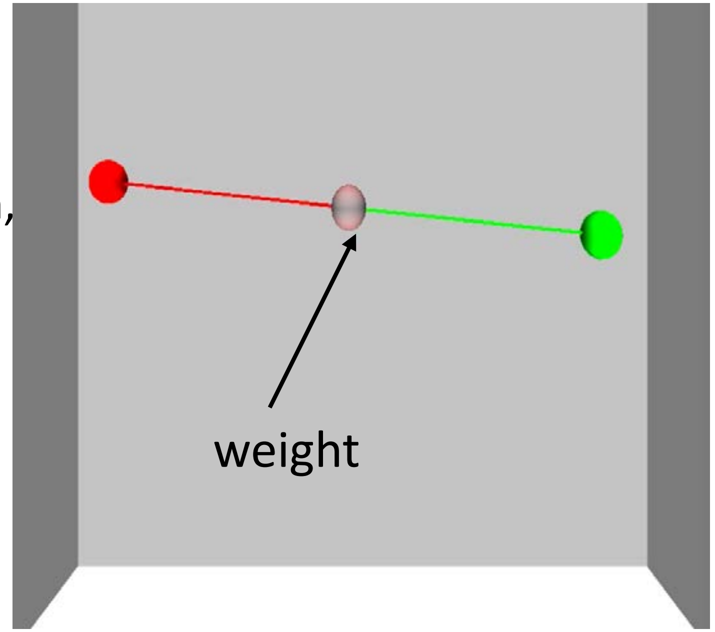


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# Purpose [2/4]

Previous work2

*2 Taguchi *et al.*, IEICE, CQ2017-38, July 2017.

Investigate the influence of network delay and delay jitter on identification of objects in a remote robot system with haptics. *2

・The softness of objects becomes more difficult to be distinguish as the network delay increases.

# Purpose [3/4]

*3 M. Sithu *et al.*, IJCNS, vol. 8, no. 11, pp. 440-455, Nov. 2015.

Previous work3

Handle a network balloon bursting game and investigate the influence of network delay on the operability of haptic interface device for soft objects.*3

Soft objects become harder and more slippery as the network delay increases.

# Purpose [4/4]

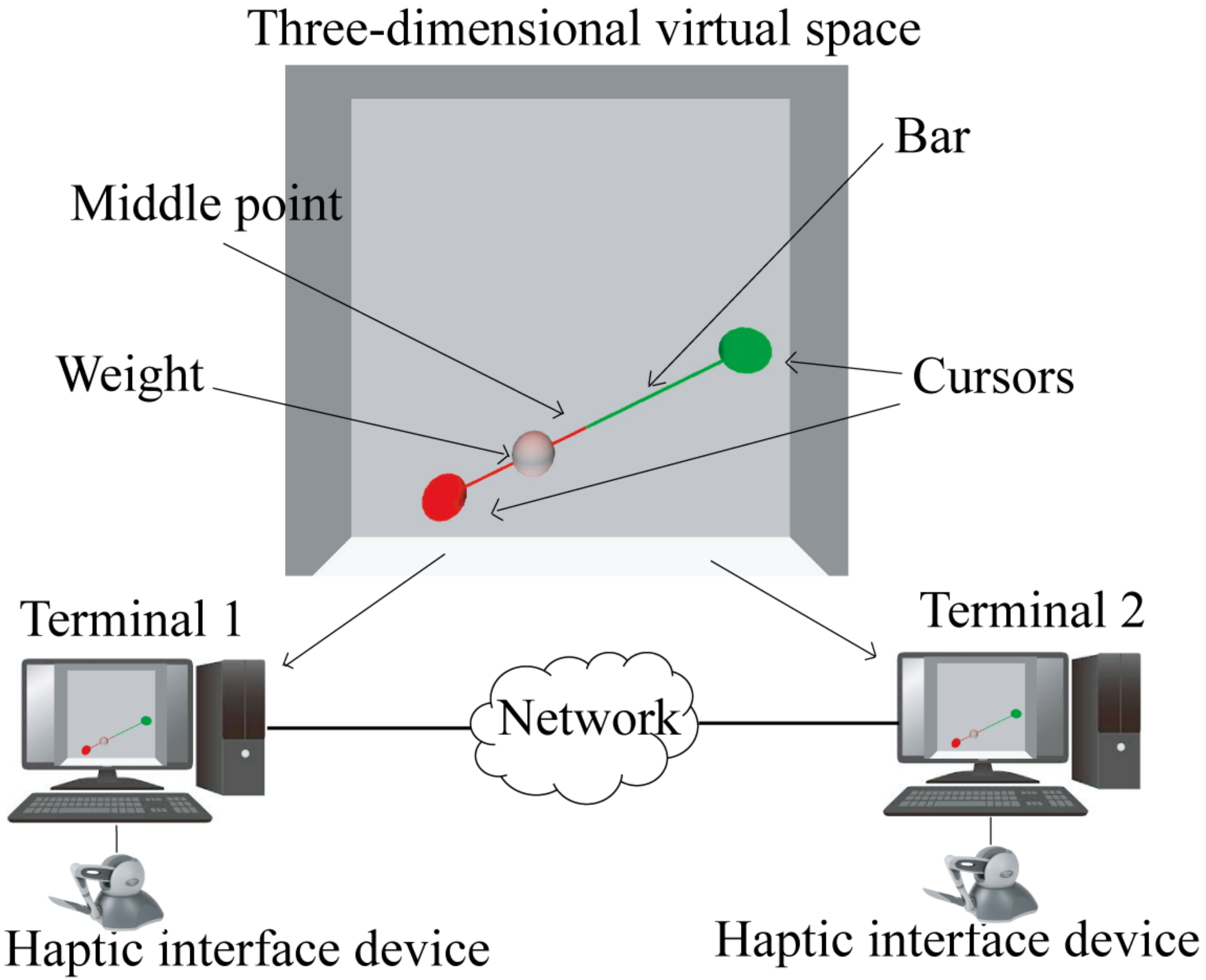
## Problem

- How the weight of an object can be perceived correctly by haptic feedback has not been sufficiently clarified so far.

## This work

- Examine how correctly users can perceive the change of the weight in the weight balance system.

# Configuration of Weight Balance System

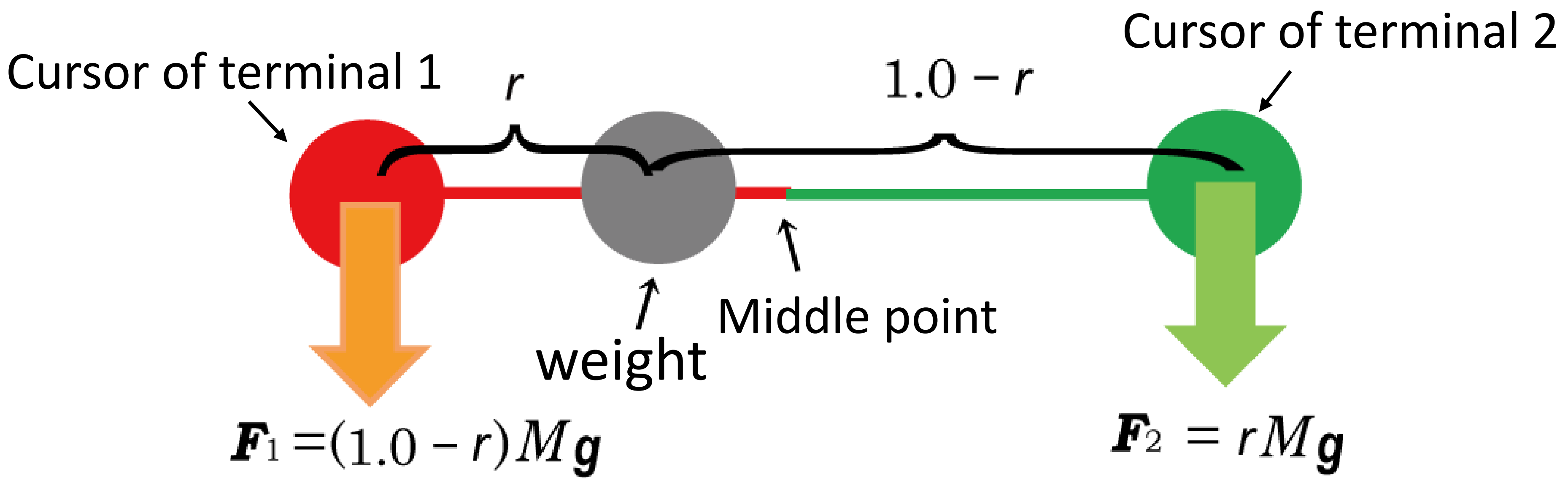


# Calculation of Weight

$\boldsymbol{Mg}$ : Weight of the weight（$M$: Mass of weight ,

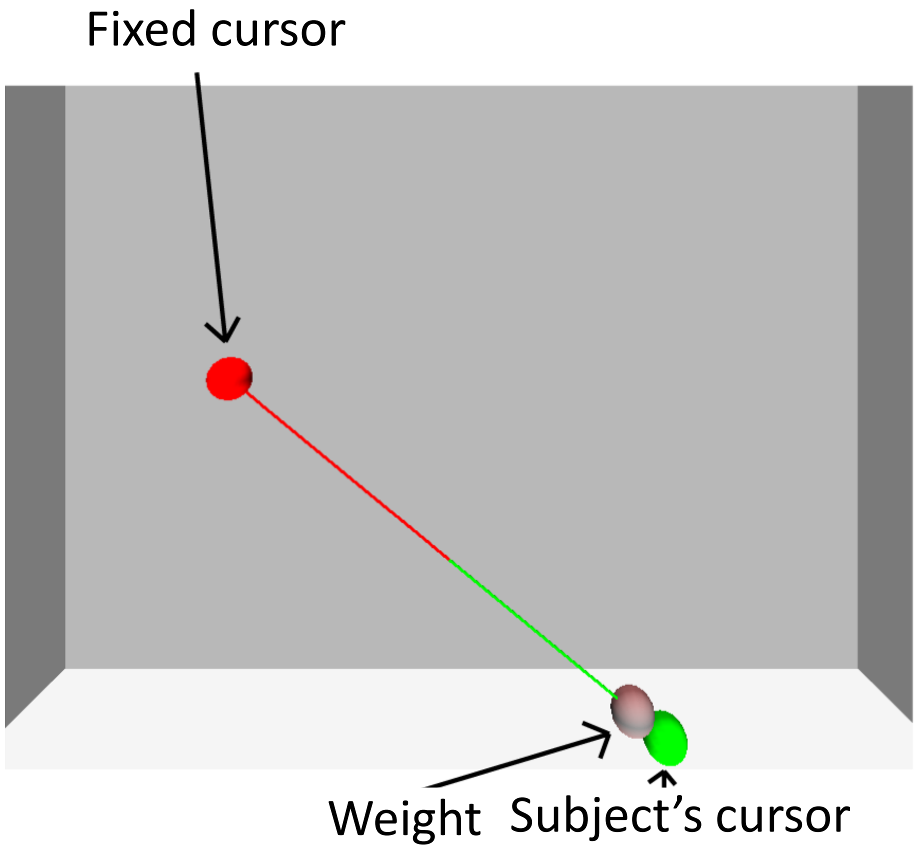
$\boldsymbol{g}$ : Gravitational acceleration）

$r$ : Proportion of distance from weight to cursor of terminal 1



# Assessment Method (1/3)

- Cursor on the one side is fixed (this height corresponds to the position by 5cm high from the initial position in the real space.).
- Moves the weight so that the weight comes to the middle point at  the two cursors.
- When the weight is located at the middle point, each subject feels half the weight.
- The subject tries to keep the weight at the height.




Displayed image of 3D virtual space at beginning of assessment.

# Assessment Method(1/3)

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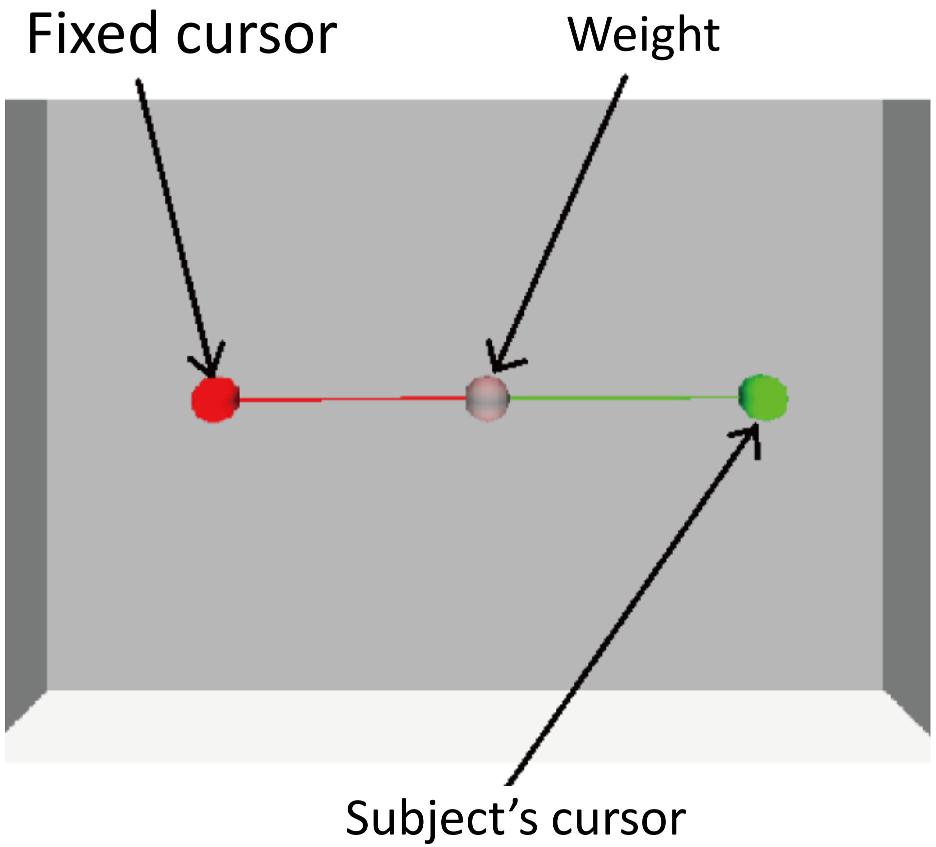



Displayed image of 3D virtual space immediately before weight change

# Assessment Method(2/3)

- Change the weight immediately to the other values (including the same value). Then, each subject selects one from among the three answers “lighter”, “same”, and “heavier” compared with the *standard weight*.
- Handle three kinds of weight, that is, 1 time, 1/2 times, and 1/4 times of 270 gf.

(the *standard weight* is 135 gf, 67.5 gf, and 33.75 gf, respectively)

- Range of weight change

✓Cases of 1 time and 1/2 times

－50 gf to +50 gf at 10 gf intervals

✓Case of 1/4 times

－30 gf to +30 gf at 10 gf intervals

Including the same value, present different weights 3 times (totally, 33, and 21, respectively)

- Present the stimuli in  random order for each subject.

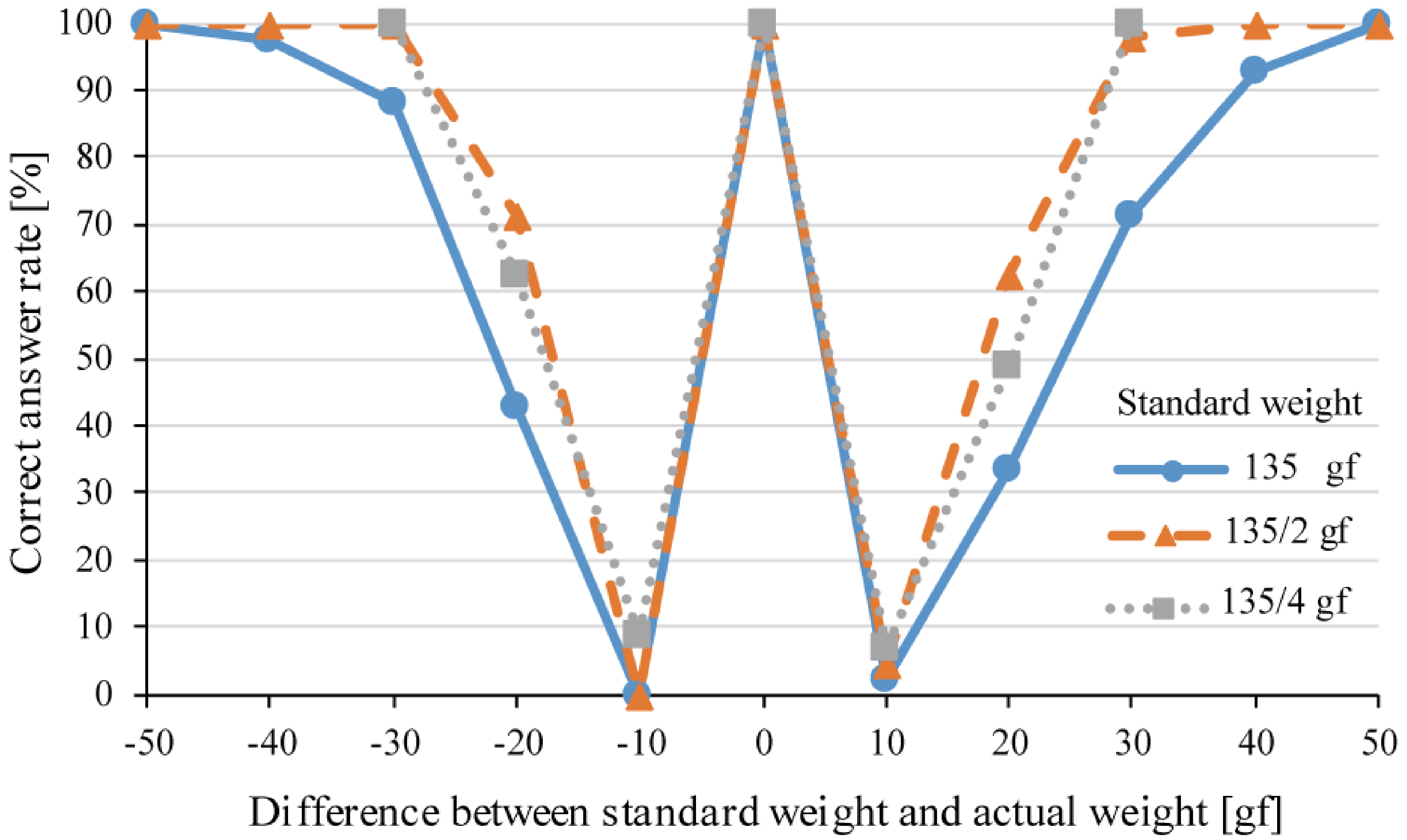
# Assessment Method (3/3)

- Correct answer : If the sign of the difference between the standard weight and actual weight is

$$\left.\begin{array}{r} \text{positive ,}\\ \text{negative,}\\ 0 \quad ,\end{array}\right\}\ \text{correct answer is}\ \left\{\begin{array}{l} \text{“heavier”.}\\ \text{“lighter”.}\\ \text{“same”.}\end{array}\right.$$

- Correct answer rate: Number of correct answers divided by total number of answers × 100（%）
- Subjects : 15 men whose age were between 21 to 24.

# Assessment Results




light

heavy

# Conclusion

We investigated how accurately users can perceive the change of the weight by handling a weight balance system.

- Can hardly perceive the absolute weight changes less than or equal to about 10 gf.
- Start to perceive the absolute weight exceeding about 20 gf.
- There is almost no difference in weight perception between the case it gets lighter and the case heavier.

# Future Work

- How largely network delay, delay jitter, and packet loss affect weight perception.
- Investigate weight perception in real environment such as in remote robot systems with haptics.