QoE Assessment of Weight Perception in Remote Robot System with Force Feedback

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Background (1/2)

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

A user can operate a remote industrial robot through a haptic interface device while watching video.

- **By using the haptic interface device, we can perceive the shape, weight and softness of a remote object which is touched by the robot arm.**

It is expected that the efficiency and accuracy of work can largely be improved.

Background (2/2)

When information regarding force is transferred 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**
- **Stabilization control**

In order to make the control efficiently

We need to clarity the human perception.

Purpose (1/3)

*1 Q.Qian *et al.*, Proc. IEEE ICCC, Dec.2018

Previous work 1

- **Investigate to what extent humans can accurately perceive the force direction via a haptic interface device[*1].**

More than about 80% subjects can feel the force and answer the correct directions when the absolute value of force is stronger than about 0.2 N in each direction.

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

Purpose (2/3)

Previous work 2

- **Assess influences of weight perception through a weight balance system with haptics in which two users cooperatively lift a weight vertically in a three-dimensional (3D) virtual space [*2] .**

Subjects hardly feel the absolute weight changes lighter than or equal to about 10 gf.

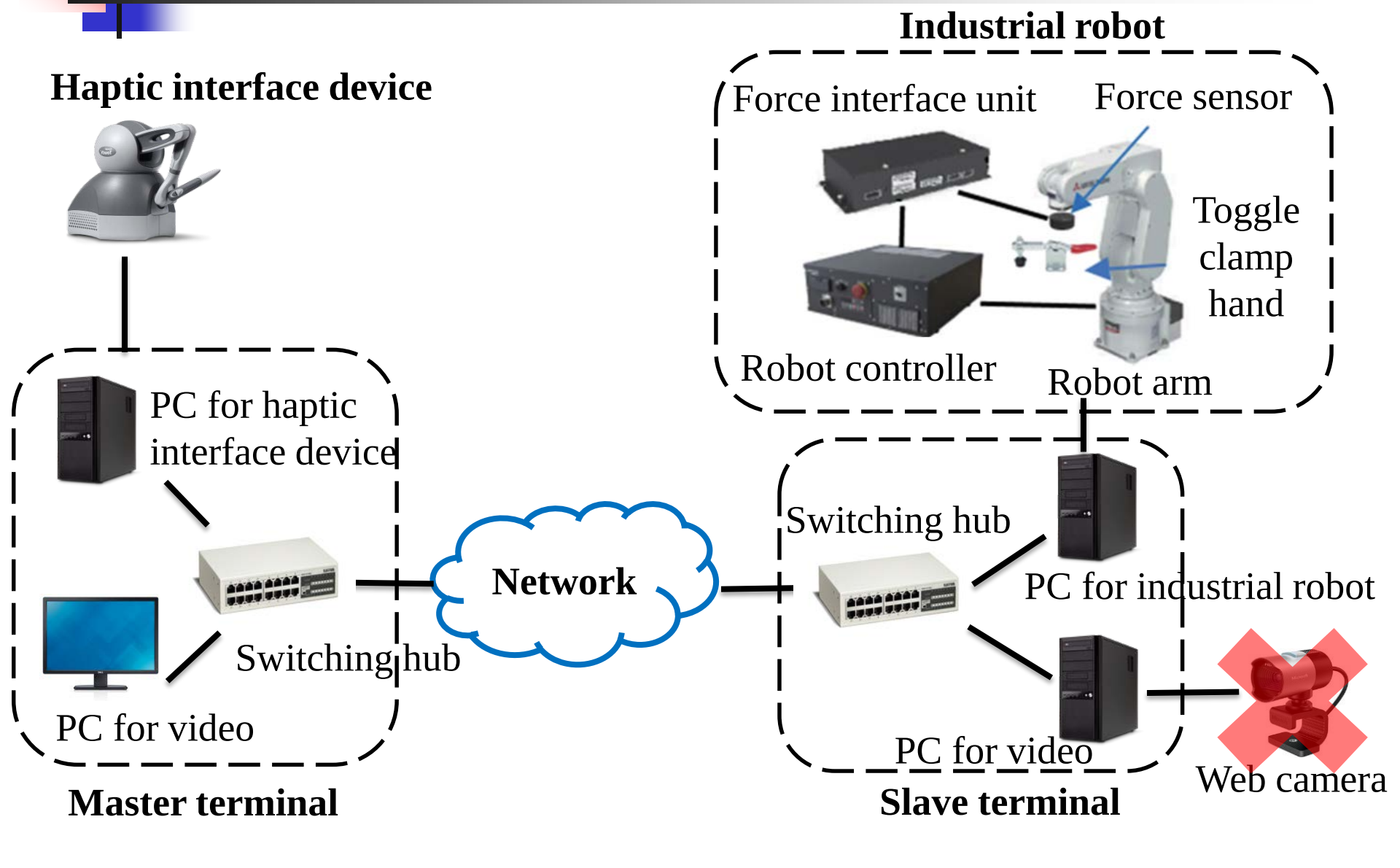
It is also necessary to clarify the human perception in a real space.

Purpose (3/3)

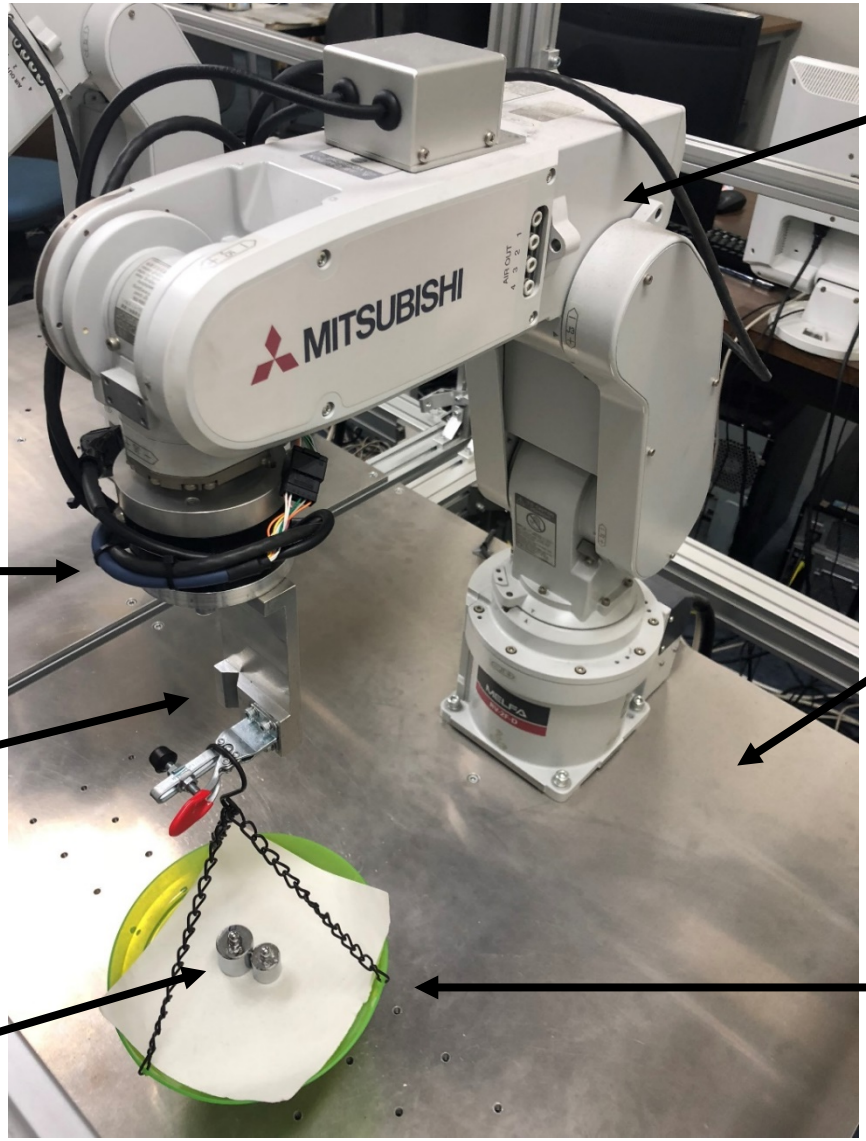
This work

- **We investigate human weight perception in a real space through the remote robot system with force feedback by QoE assessment.**
- **We assess what extent weight change each subject perceives after changing the weight hung from the industrial robot arm.**

Remote Robot System with Force Feedback



Industrial Robot Arm



Industrial robot arm

Force sensor

Toggle clamp hand

Weights

Metal platform

Hanging plate

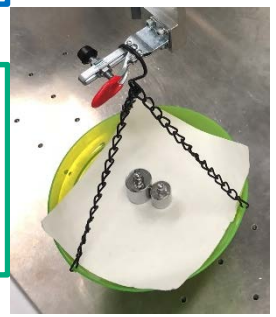
Assessment Method (1/2)

Master terminal:

- **Each subject holds and keeps the stylus of the haptic interface device at the same position.**

Industrial robot:

We change the weight on the plate at a time.



- **The weight before change is called the standard weight here.**

- **The subject will answer whether the weight has been changed or not compared with the standard weight.**

- **There are three choices for the subject: "lighter," "no change," and "heavier."**

Assessment Method (2/2)

Set A:

Standard weights	Range of change
50 gf	−50 gf～+50 gf
100 gf	−70 gf～+70 gf
150 gf	−70 gf～+70 gf
250 gf	−70 gf～+70 gf

15 subjects (8 males and 7 females).

Set B:

Standard weights	Range of change
30 gf	−30 gf～+30 gf
60 gf	−50 gf～+50 gf
120 gf	−50 gf～+50 gf

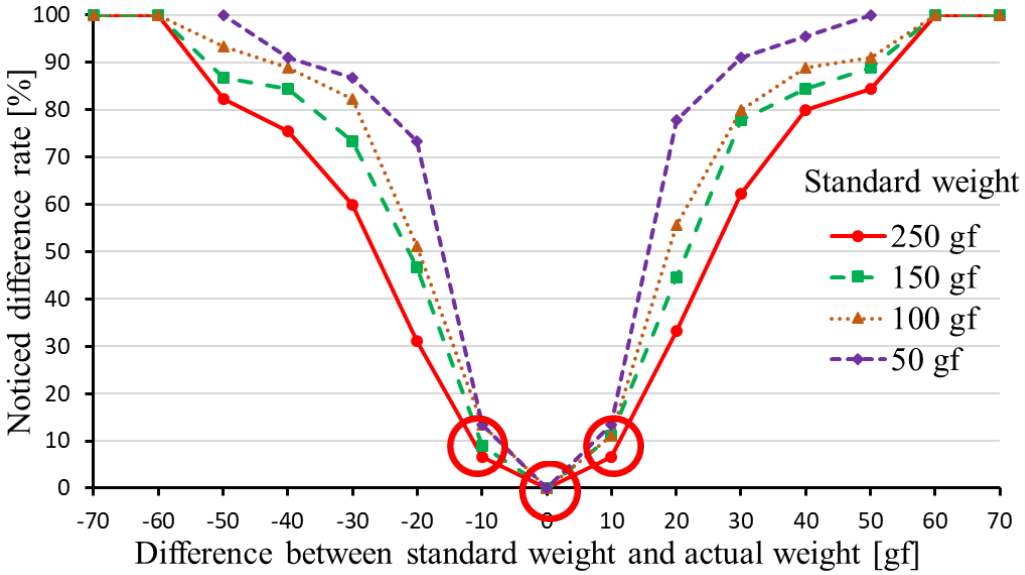
15 subjects (15 males).

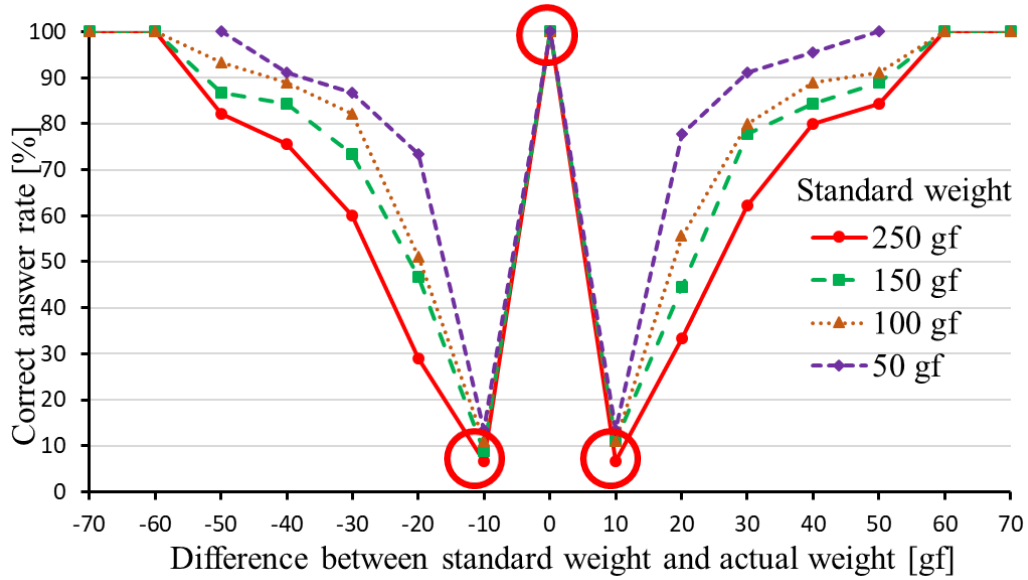
- **The negative value means that the weight after change is lighter than the standard weight, and the positive value does that the weight after change is heavier.**

The standard weights and the weight after change were presented in a random order for each subject and for each set.

Assessment Results (1/2)

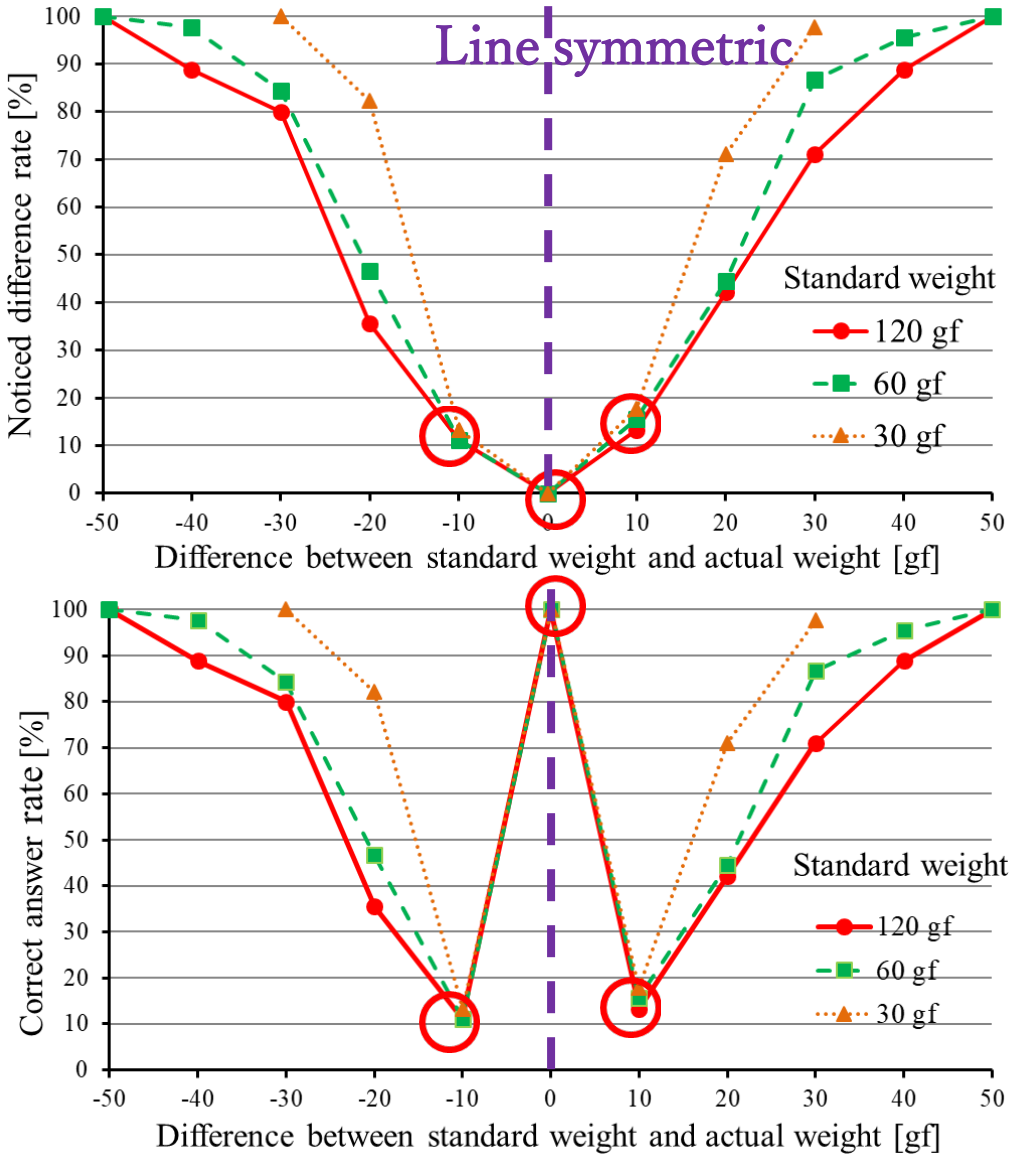
Set A:





Assessment Results (2/2)

Set B:



Conclusions

We assessed human perception of weight and investigated what extent each subject perceives the change of weight by using the remote robot system with force feedback.

- **The subjects can hardly perceive the weight change within 10 gf.**
- **When the absolute difference is about 20 gf ,the subjects start to perceive the change of weight.**
- **When the absolute value of difference weight is above around 30 gf, most of the subjects can perceive the change of weight.**

Future Work

- **Plan to study QoS control by using the results of this work, and investigate the effect of the control.**

- **Investigate the influence of stabilization control on the weight perception.**