Enhanced Robot Movement Control Using Force Sensor in Remote Robot Systems Taking Account of Mobility

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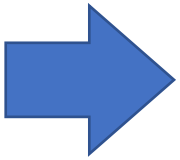
Background

Remote robot systems with force feedback

- Possible to perceive the shape and weight of object hit/touched by a remote robot having a force sensor through a haptic interface device
- Possible to carry an object as cooperative work between two remote movable robots



When sudden large position change on uneven road occurs, the object may be broken.

Position correction is needed for sudden large position change.

Previous Work *1

- ✓ Cooperative work of carrying an object by using two remote robots
- ✓ Sudden position change of one robot in the up-down direction while two robots are moving in front-back direction
- ✓ Several types of robot movement control are applied to the up-down direction

Robot movement control using motion equation is the most effective.

→ *Quick suppress of force in the up-down direction*

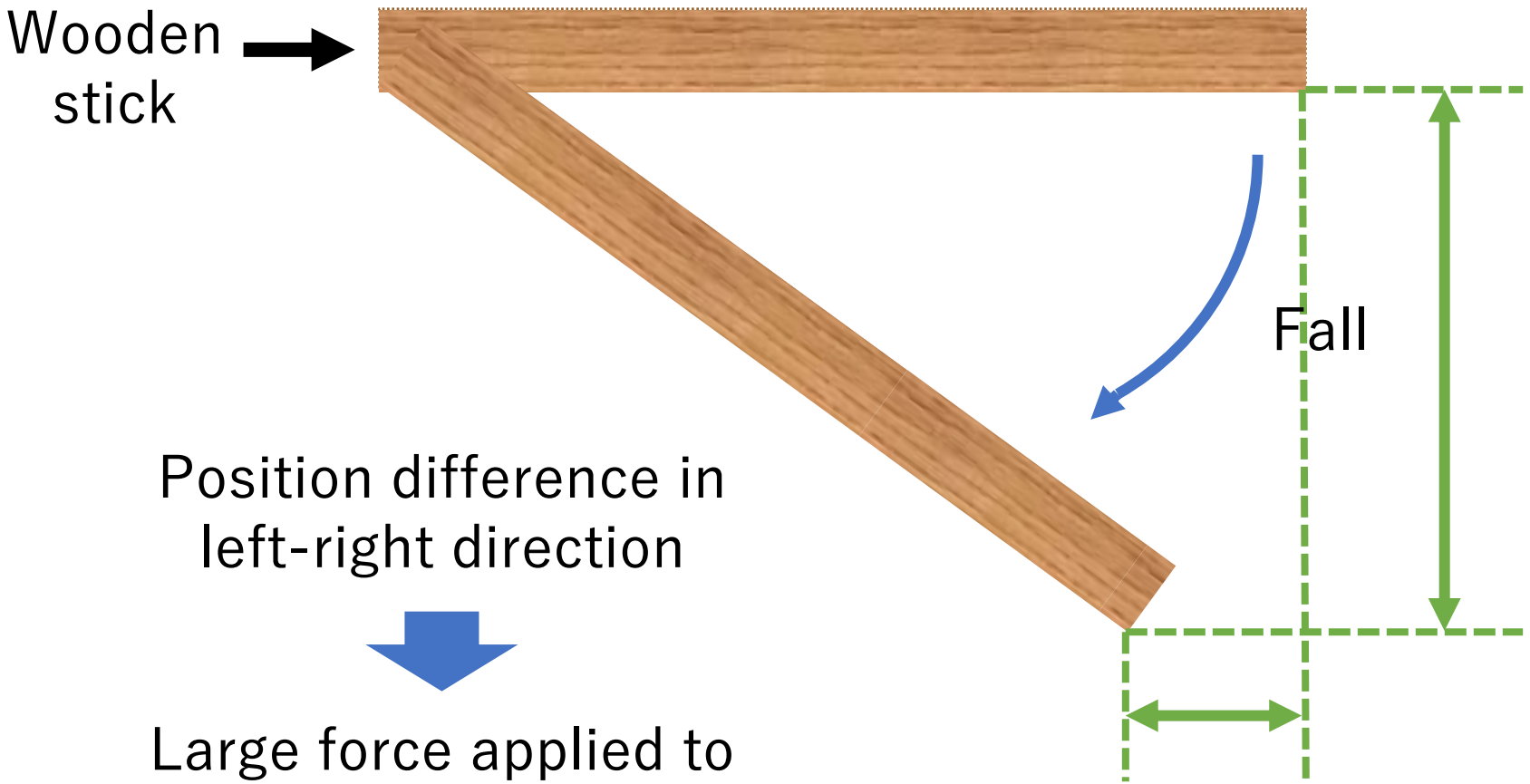
Problem

Large force applied to object in the left-right direction has not been solved.

*1 H. Nakagawa *et al.*, IEICE Technical Report, CQ2022-64, Jan. 2023.

This Work (1/2)

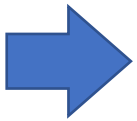
Position change of only one robot in up-down direction



This Work (2/2)

Previous work

Up-down direction



Up-down direction + Left-right direction

This work

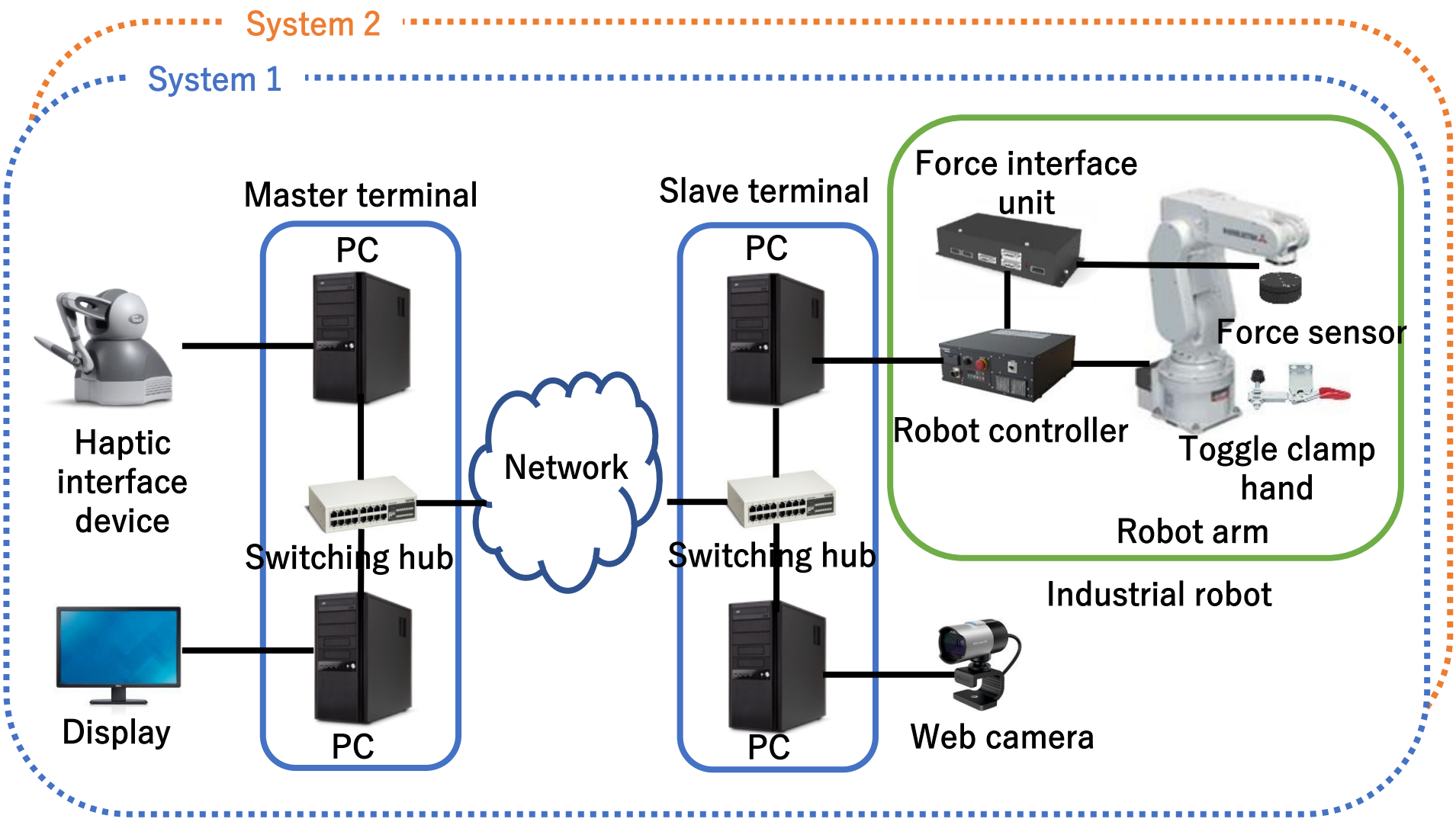
Robot movement control is applied to the left-right direction

Alleviate force applied to the left-right direction when the position change occurs in the up-down direction

Make a comparison among the following three cases in which the control is performed:

- ✓ Only one system which falls largely
- ✓ Only the other system
- ✓ Both systems

Remote Robot Systems with Force Feedback



Robot Movement Control

Robot position adjustment [*1]

$$\boldsymbol{P}_t = \alpha \boldsymbol{P}_{t-1} + K\boldsymbol{F}_t$$

$\boldsymbol{P}_t$: Position adjustment vector
α : Constant
K : Constant
$\boldsymbol{F}_t$: Force detected by force sensor

✓ Up-down direction: $K = 0.349, \quad \alpha = 0.95$ [*2]

✓ Left-right direction:

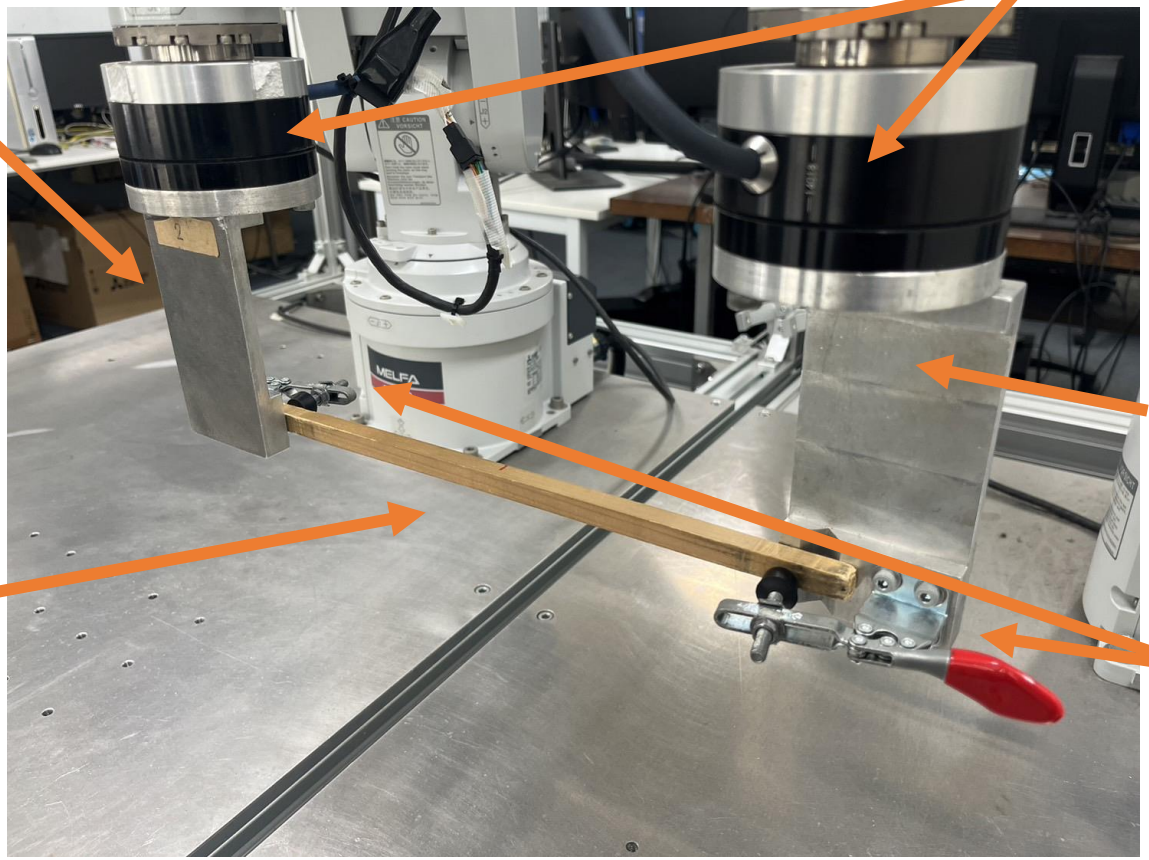
$$K = 0.112 \text{ [*3]}, \quad \begin{cases} \alpha = 0.45 & \text{(Only one system)} \\ \alpha = 0.20 & \text{(Both systems)} \end{cases}$$

*1 Y. Ishibashi *et al.*, IEEE ICCE-TW, July 2022.
*2 H. Nakagawa *et al.*, IEICE Technical Report, CQ2022-64, Jan. 2023.
*3 Y. Ishibashi *et al.*, ICCAR, pp. 147-151, Apr. 2019.

Experiment Method (1/2)

Robot arm 2 (*manual operation*)

Force sensor



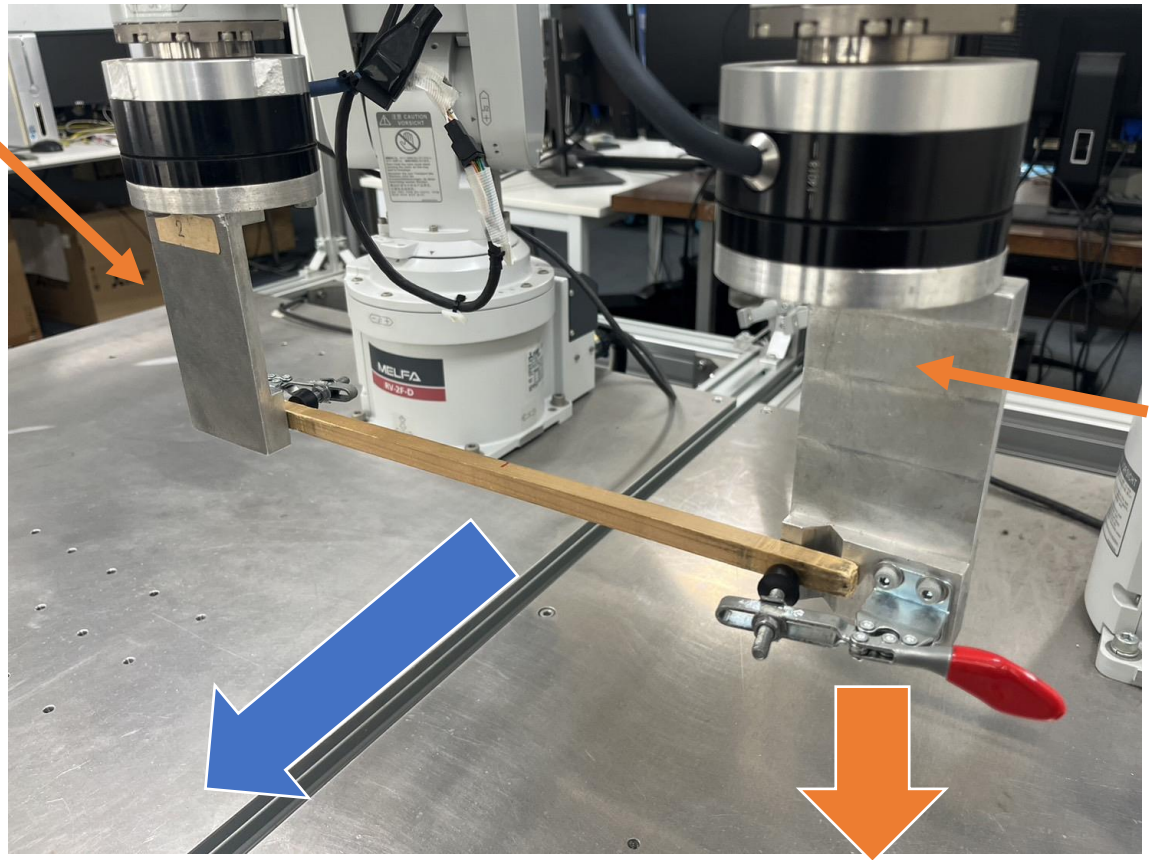
Robot arm 1 (*automatic moving*)

Wooden stick

Toggle clamp hand

Experiment Method (2/2)

Robot arm 2 (*manual operation*)



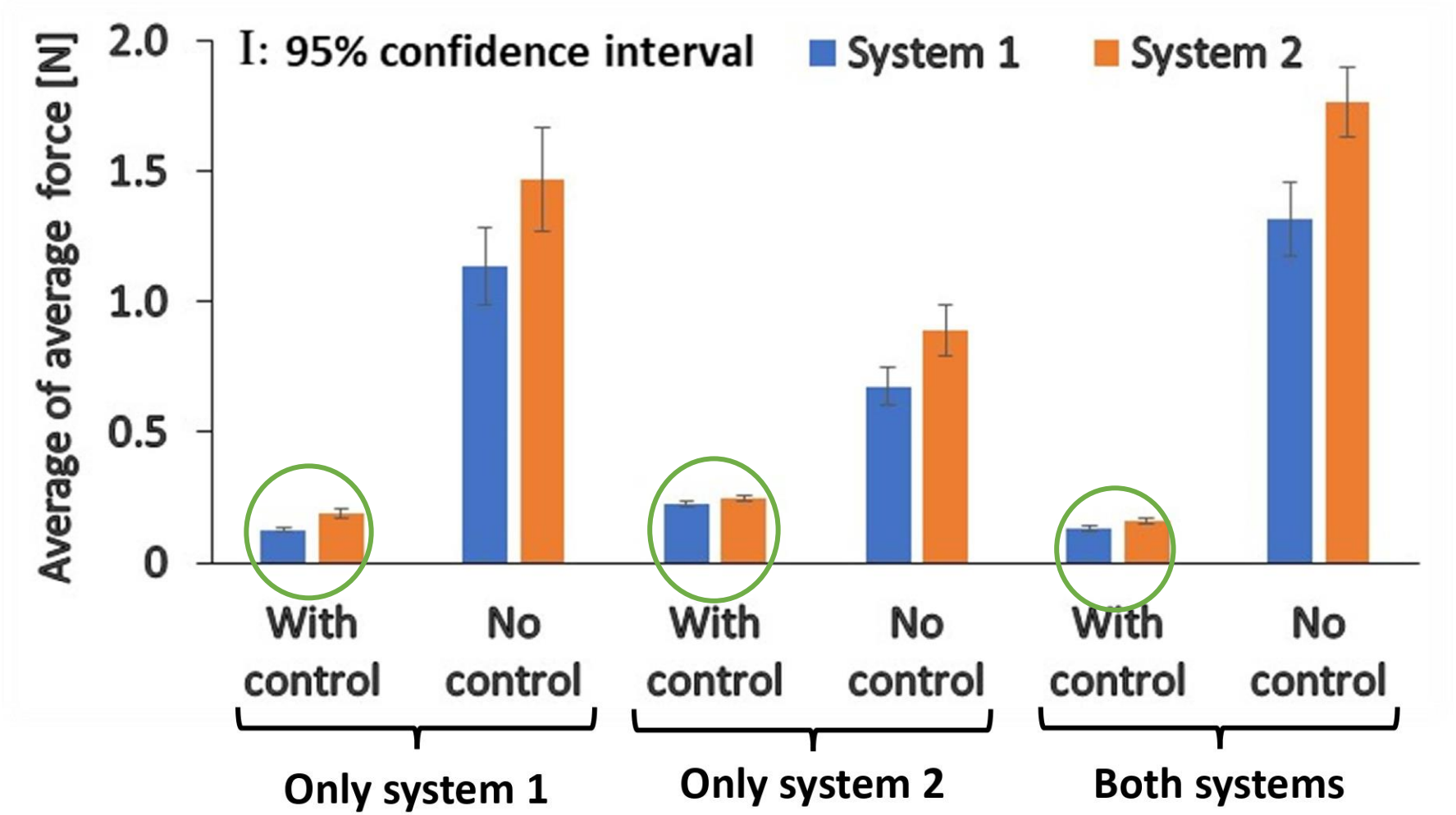
Robot arm 1 (*automatic moving*)

Movement in front direction

Fall by 20 mm

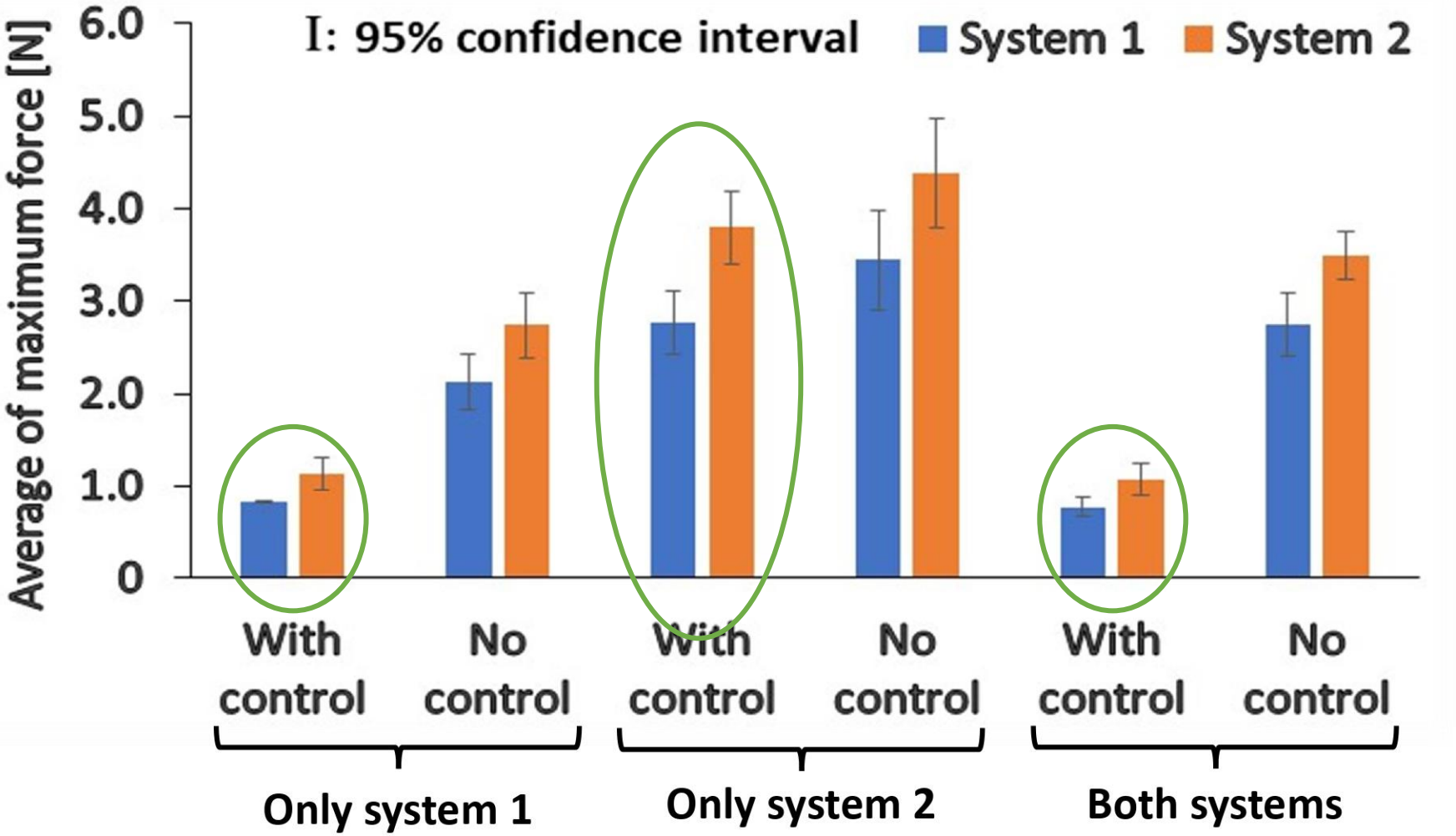
Experimental Results (1/2)

Average of average absolute force in left-right direction



Experimental Results (2/2)

Average of Maximum absolute force in left-right direction



Conclusion

Cooperative work between two remote robot systems with force feedback

- Position change of only one robot in the up-down direction
- Robot movement control is applied to the left-right direction
- Three cases in which the control is performed

✓ Robot movement control in the left-right direction is **effective**.
✓ The control should be performed **at both systems.**

Future Work

- Investigation of effects for position change in the other direction