Effect of Stabilization Control by Viscosity in Remote Control System with Haptics

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Background

- Remote control systems in which users remotely operate haptic interface devices while watching video have been actively researched.

The systems are expected to improve work efficiency largely.

When we use them through a network like the Internet, which does not guarantee the Quality of Service (QoS) .

Network delay, delay jitter and packet loss

QoE (Quality of Experience) degradation

To carry out stabilization control

*1 T. Rikiishi et al., IEICE Technical Report, MVE2017-19, Sep. 2017.

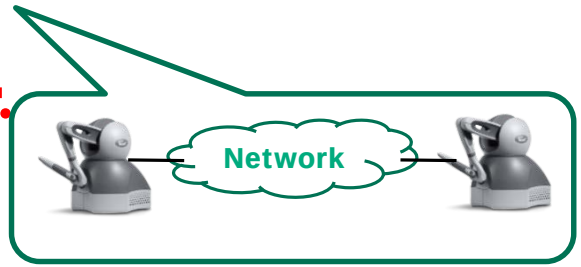
Problems

Previous work

The stabilization control by viscosity is proposed for the remote robot system with force feedback, where the effect of the proposed control is investigated by experiment*1.

The instability phenomenon has been suppressed; that is, the control is effective.

- **The control may be effective for the remote control system with haptics.**
- **The effect has not been investigated so far.**

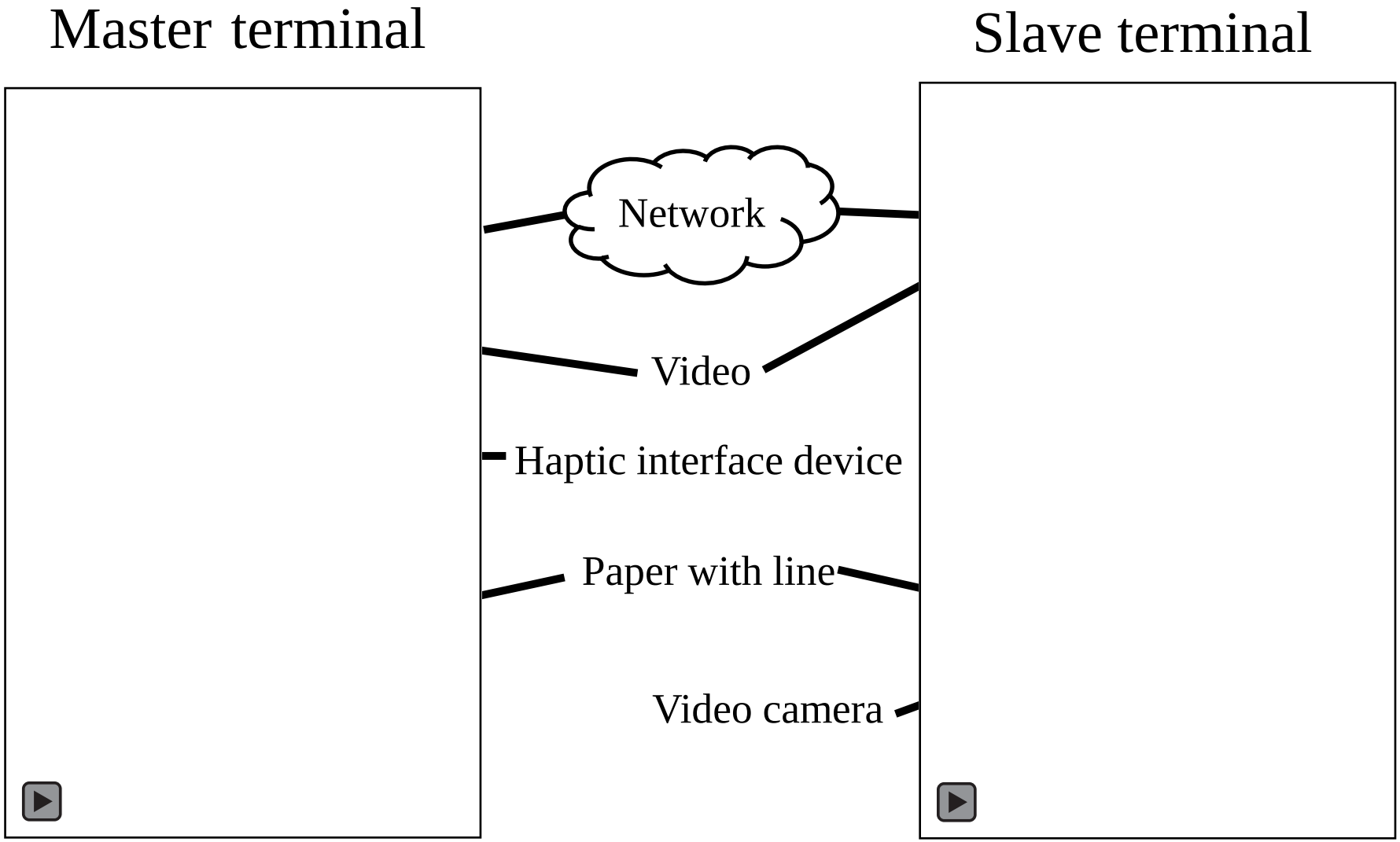


Purpose

This work

- We enhance the stabilization control by viscosity to apply the control to the remote control system with haptics.
- We illustrate the effectiveness of the control by experiment.

Remote Control Systems with Haptics



Calculation for Reaction Force

$$\boldsymbol{F}_t^{(\mathrm{m})} = K_s\left(\boldsymbol{S}_{t-1}^{(\mathrm{m})} - \boldsymbol{M}_{t-1}^{(\mathrm{m})}\right)$$

$\boldsymbol{F}_t^{(\mathrm{m})}$: Reaction force of the master terminal at time t ($t > 0$)

$\boldsymbol{M}_t^{(\mathrm{m})}$: Position vector of the haptic interface device of the master terminal at time t ($t > 0$)

$\boldsymbol{S}_t^{(\mathrm{m})}$: Position vector of the haptic interface device of the slave terminal at time t ($t > 0$)

K_s : Elastic coefficient

$$K_s = 9/(2D + 90)$$

D : One-way network delay between the two terminals

Stabilization Control by Viscosity

At the slave terminal, the haptic interface device is operated according to the position information of the haptic interface device transmitted from the master terminal.

$$\boldsymbol{S}_t^{(\mathrm{s})} = \boldsymbol{M}_{t-1}^{(\mathrm{s})} - C_d(\boldsymbol{M}_{t-1}^{(\mathrm{s})} - \boldsymbol{S}_{t-1}^{(\mathrm{s})})$$

$\boldsymbol{S}_t^{(\mathrm{s})}$: Position vector of the slave terminal at time t

$\boldsymbol{M}_t^{(\mathrm{s})}$: Position vector of the master terminal at time t

C_d : Coefficient related to the viscosity

$$\boldsymbol{F}_t^{(\mathrm{s})} = K_s\left(\boldsymbol{M}_{t-1}^{(\mathrm{s})} - \boldsymbol{S}_t^{(\mathrm{s})}\right)$$

$\boldsymbol{F}_t^{(\mathrm{s})}$: Reaction force of the slave terminal at time t ($t > 0$)

*2 T. Abe et al., IEICE Technical Report, CQ2018-60, Aug. 2018

Experiment Method

- **To investigate the effect of the stabilization control by viscosity, we conducted work in which a user moves the haptic interface device to right and left (in the x axis direction) along a line with length of 16 cm drawn on a paper [*2] under the control and no control.**

- **We set C_d = 0.936.**

- **We measured the position in the *x* axis of the haptic interface device of each terminal.**

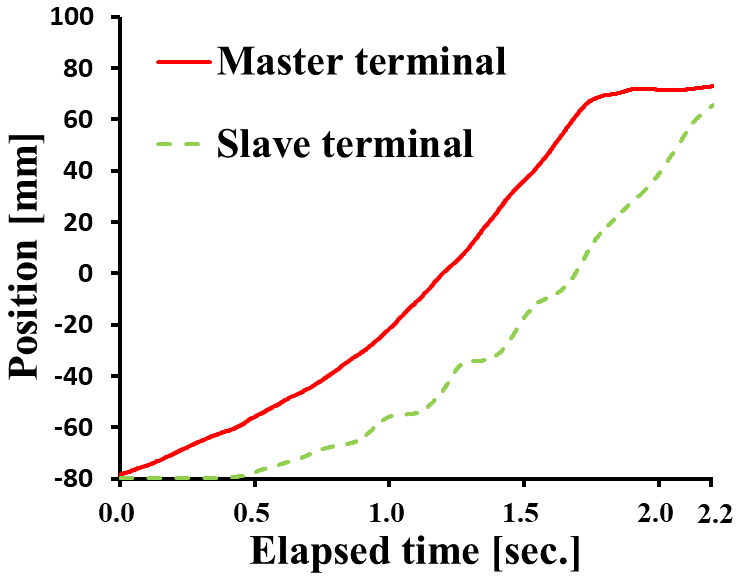
Demo Videos

No control

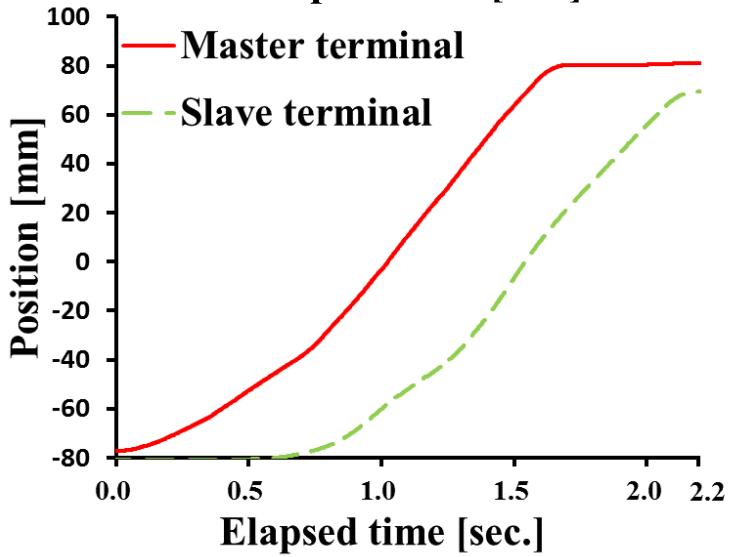
Control

Assessment Results

(a) No control



(b) Control



Conclusions

- We proposed the stabilization control by viscosity for the remote control system with haptics.
- We investigated the effect of the proposed control by experiment.

We found that the stabilization control by viscosity can suppress the instability phenomenon.

Future Work

- We plan to compare the stabilization control by viscosity and the adaptive viscoelasticity control which also can suppress the vibration.