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# Exploring Factors Influencing Cybersickness and Workload in VR Robot Teleoperation Systems under Spatial and Temporal Noise

Mark Roland Aquino[1], Yuto Hattori[1], Yutaka Nakamura[2] and Yuya Okadome[1,2]

***Abstract*— Robot remote control systems proposed for society have included approaches that utilize VR equipment, but concerns related to cybersickness still persist. In this paper, we develop a robot remote control VR simulation system that implements spatial and temporal noises, robot vibration during moving, and network connection lag-induced delays and stalls. Using this system, we investigated factors influencing the onset of cybersickness and operational workload during remote control. The experimental results suggest that communication lag may influence the onset of cybersickness. It is considered that the unpredictable nature of stalls prevents user adaptation. Regarding workload, individual spatial or temporal noise had little effect. On the other hand, a combination of robot oscillation and communication lag led to a stronger perception of workload, suggesting that the interaction of these factors increases the operational burden. Designing a human-friendly control interface of a teleoperation mobile robot by using these insights is our future project.**

## I. INTRODUCTION

In recent years, remote control robot systems designed for human interaction are expected to play an increasingly important role. An example is the use of the OriHime avatar robot at “Avatar Robot Cafe DAWN ver.$\beta$” [16], which facilitates communication for individuals with severe physical disabilities. Similarly, Telexistence introduced the MODEL-H robot and a VR system [2] to achieve more immersive teleoperation. Stotko et al. [14] also developed a VR-based system for immersive robot teleoperation. Thus, the adoption of VR devices is emerging as an important option for enhancing teleoperated robotic communication.

However, systems utilizing VR equipment often induce cybersickness (motion sickness-like symptoms) in operators, particularly during movement within the virtual environment. In VR-based robot teleoperation, additional factors such as communication lags (due to wireless connections) and visual shaking (caused by robot movement) further contribute to the onset of cybersickness [15]. Cybersickness in robot teleoperation systems reduces user concentration and judgment, thereby degrading task efficiency. Furthermore, the resulting physical and psychological stress can limit long-term system operation and lead to user refusal to use a teleoperation system.

In this study, we developed a VR robot teleoperation simulation system that reconstructs the visual shaking of the robot’s camera image and the operational instability (temporal perturbation of communication) typically encountered when operating a mobile robot. The proposed system models the camera image shaking as spatial noise and the delayed operation and stalls (resulting from communication disruptions) as temporal noise. A stall is defined here as a phenomenon of pseudo-burst transmission, typically resulting from momentary disconnections followed by the simultaneous arrival of multiple commands. Although stall noise frequently occurs in robotic applications, it is often not distinctly considered in previous simulations. However, given that a primary assumption for the mechanism of cybersickness is perceptual discrepancies (sensory conflict), we specifically designed and implemented stall noise within our simulator. We investigated the effects of individual noise factors and their combination on cybersickness.

We conducted a robot teleoperation experiment using the proposed VR system to subjectively evaluate and analyze the factors affecting cybersickness and workload. Participants controlled a robot performing an office environment patrol task in the VR space. Preliminary results indicate that the stall noise significantly affects the onset of cybersickness. Furthermore, the workload results suggest that while individual spatial or temporal noise factors have no large effect compared to a noise-free system, the combination of these two factors increases the perceived workload.

## II. RELATED WORKS

The primary hypothesis for the onset of cybersickness is the sensory conflict (perceptual discrepancy) between the user’s vestibular sensation (which controls equilibrium) and the visual information presented in the virtual environment [8], [1], [17]. The manifestation of cybersickness, often attributed to inconsistencies in spatial perception, is frequently investigated using passive VR image viewing rather than interactive, manipulable systems [11], [22]. Since these evaluations often rely on passive exposure, it is also crucial to investigate subjective experiences and physiological effects in actively controlled systems, such as remote robot teleoperation.

### A. Cybersickness Evaluation Indicators

There are two main categories of indicators used to evaluate cybersickness: physiological reactions [11], [22] and subjective evaluations [7], [12]. In some studies, physiological reactions are used as indicators of symptom onset [11], [22]. Common physiological measurements often include heart rate variability and galvanic skin response [9].

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[1] Mark Roland Aquino, Yuto Hattori and Yuya Okadome are with the Department of Information and Computer Technology, Faculty of Engineering, Tokyo University of Science. `okadome@rs.tus.ac.jp`

[2] Yuya Okadome and Yutaka Nakamura are with Guardian Robot Project, RIKEN Information R&D and Strategy Headquarters, RIKEN.

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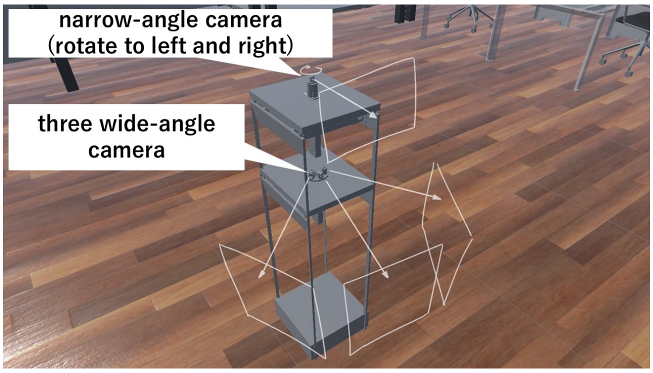

Fig. 1: The structure of a virtual moving robot. Three cameras are used to watch the robot's lower frame. The other camera is for looking around the environment. The forward, backward, and rotation behaviors are implemented on the robot's wheelbase.

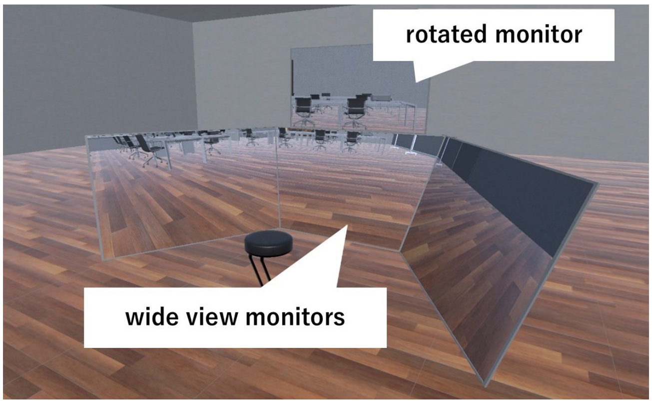

Fig. 2: Control interfaces for the robot operation. Three lower monitors are to show a participant the information during the robot moving. One upper monitor is to watch detailed information for tasks.

For subjective evaluation, the Simulator Sickness Questionnaire (SSQ) [6] is the most frequently used tool for VR applications [13]. The questionnaire consists of 16 items, where participants rate the severity of symptoms for each item on a scale from 0 (no symptoms at all) to 3 (symptoms to a great extent). Alternative tools, such as the Cybersickness in Virtual Reality Questionnaire (CSQ-VR) [7] and the Virtual Reality Sickness Questionnaire (VRSQ) [7], have also been developed [12]. Furthermore, Mishina et al. [10] proposed a cybersickness evaluation method that utilizes the correlation between SSQ results and physiological indicators.

### B. *Cybersickness in Robot Teleoperation*

In the context of robot systems, Suomalainen et al. [15] found that the degree of cybersickness did not correlate with the speed of the robot's turns in an experiment where participants were shown a video of an autonomous robot moving through a virtual space. They also mention the predictability of the robot's turning as a potential factor in the onset of cybersickness. However, since participants were passively observing the robot in that study, the influence of system factors, such as communication lag and noise, on cybersickness during active robot control remains uninvestigated.

## III. VR ROBOT TELEOPERATION SYSTEM

In this study, a VR robot teleoperation simulation system was developed to investigate the relationship between robot operation and cybersickness using VR devices. Noises such as shaking and communication lag that occur in the teleoperation of a real robot are implemented in our system. The simulation environment used was Unity[1], a game engine. The target FPS of rendering the simulation environment was set to 120 FPS for reducing the flickering. For the head-mounted display (HMD) worn by the user, Quest Pro[2], which can acquire estimated values of gaze point and facial expressions in addition to head tilt, and SteamVR (OpenXR)[3] were used to run the VR application instance.

The virtual field in the system consists of two spaces: the operation room, which serves as the operation interface presented to the user, and the office room where the robot operated by the user moves. The robot is equipped with a camera and can explore the office room by looking at the monitor projected in the operation room.

### A. *Configuration of Mobile Robot in Virtual Space*

The configuration of the virtual robot is shown in Fig. 1. The robot in the virtual space has a narrow-angle camera that can rotate to look left and right for showing detailed information and three wide-angle cameras for checking surrounding situation. The robot also has a hit detection and collides with walls and obstacles in the virtual space room.

Because the role of wide-angle cameras is to scan the surroundings, the wide angle of the field and low-fidelity images are projected onto three monitors, i.e., it is difficult to see the detailed information, such as characters. Meanwhile, because the narrow-angle camera is used for capturing detailed information, the narrow angle of the field and high-fidelity image is projected onto one moving monitor, i.e., it is difficult to catch the sense of distance. By employing multiple cameras for each purpose, moving and watching, it is expected that participants cope with various situations during remote control of a system [21].

### B. *Robot Operation Interface*

In the virtual space, four monitors are placed in front of the operator's viewpoint, as shown in Fig. 2. Three monitors placed at a lower position shows a wide view of the robot from the front of the robot to its lower body. One upper monitor shows the front of the robot for a detailed view, and the monitor can be rotated to the left or right based on the operator's head motion.

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[1] https://unity.com

[2] https://www.meta.com/jp/quest/quest-pro/

[3] https://store.steampowered.com/app/250820/SteamVR/

The keyboard interface is used to control input for the robot simulation. The robot can move forward/backward and turn left/right by typing the arrow keys, just like a typical mobile robot [20]. In addition, by pressing SPACE keys on the keyboard, the robot zoom in and out of the image on the monitor that shows the front view.

### C. Noise Designs

We assumed that the factors that affect the onset of cybersickness in a robot teleoperation VR system are a mismatch of physical sensors, *e*.g., the perturbation of the robot body during movement, the time lag in wireless communication, and communication stalls caused by switching wireless access points. We implement these spatial and temporal factors in this system.

To reconstruct the perturbation of the robot, we applied slight angular vibrations (yaw and pitch directions) to the optical axes of all cameras while the robot was moving. The noise is sampled from a uniform distribution $\mathcal{U}$, and a moving average value is used to prevent the suddon change of variables

$$n(t) \leftarrow \alpha n(t-1) + (1-\alpha)n, n \sim \mathcal{U}(-L, L), \quad (1)$$

where $L$ and $n$ are the range of random variables and sampled noise value, respectively. In each frame $t$, if the absolute velocity value of the robot $v$ exceeds the threshold value, the yaw component of the camera object is updated with the following formula.

$$\mathrm{yaw}(t) \leftarrow \mathrm{yaw}(t) + n(t) \quad (2)$$

We implemented delay and stall as the temporal noise ( communication lag). For the time delay, the control signal is always reflected 15 frames (about 0.13 seconds) later. This delay simulates the connection speed of WiFi devices.

For a communication stall, the input operation is fixed for 100 frames (about 0.83 seconds) with a probability of 0.0015% per frame (average 1.08 times per minute). This allows the robot to make unexpected movements, for example, the robot continues to turn left for a short time even if the operator stops inputting a command. This frequently happens for the teleoperation of moving a robot, *e.g.,* switching a WiFi access point.

## IV. EXPERIMENT

In this experiment, we use a developed remote control simulator to subjectively evaluate and investigate the factors that cause the onset of cybersickness.

### A. Experimental Setup

The experiment consists of four sessions under the following conditions: noise free (ideal), shaking of image stream (shake), time lag in communication and communication stall (lag), and combination of the shake and lag (all). Questionnaire results and the neck behavior are collected for each session.

The robots in the virtual space are placed in an office-like space with tables, whiteboards, and partitions. Participants must avoid these obstacles and operate the robot appropriately to complete the task. For each session, the task includes questions that can be answered by observing the paintings and small objects placed in the room, such as “Answer the solution to the simple addition on the wall across from you” or “Answer the number of adult males depicted in the painting”. The text describing the task will be placed in four locations in the virtual space. We designed this task as a gamification of a surveillance task with a teleoperated moving robot. Thus, the flow of the task is a game-like sequence, *i.e.,* identifying problems while moving the robot, and then solving them.

### B. Experimental Procedure

The order of four conditions is randomly assigned for each participant in order to minimize order effects. Participants are given sufficient rest between sessions to recover from fatigue before starting the next session.

The participants operated our VR simulation system and performed tasks in the VR space. The task is working around the office envronment, and participants verbally answered easy questions put on the envioment to the experimenter. After correctly answering all the prepared questions, participants answered both the Simulator Sickness Questionnaire (SSQ) [3] in Japanese and the NASA Task Load Index (NASA-TLX) [18] questionnaire.

The SSQ was translated into Japanese as presented by Hirayanagi [5]. The SSQ is an index for evaluating the feeling of sickness and discomfort felt by the participant in the simulation environment, and measures physical reactions (e.g., fatigue), especially due to visual and motor discrepancies.

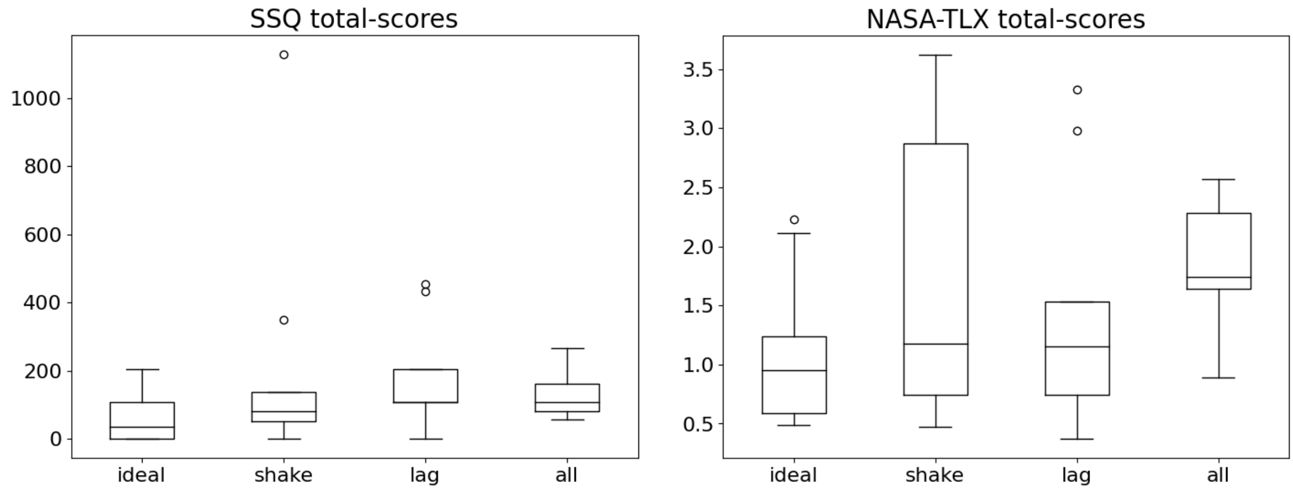
The score for each questionnaire item in NASA-TLX is a continuous scale [4], and a line was printed on a paper and the respondents were asked to strike the line. When calculating the NASA-TLX overall score, the Raw NASA-TLX method [19] which adds each factor, was used. The NASA-TLX is the index for evaluating workload, measuring six factors: Mental Demands, Physical Demands, Temporal Demands, Performance, Effort, and Frustration. For the SSQ and NASA-TLX results, an overall score of the questionnaire was calculated for each experiment in four groups: ideal, shake, lag, and all.

In addition to the participant's questionnaire results, the estimated values of neck angle (yaw and pitch) are measured from the HMD worn by the operator during task work and recorded with time stamps.

### C. Experimental Results

Eleven participants (nine men and two women, 21-32 years old), evaluated the onset of cybersickness and task workload. Because the SSQ scores of two participants are 0 for all conditions, these participants are excluded from the analysis.

The SSQ and NASA-TLX results are shown in Fig. 3a and Fig. 3b, respectively. From both SSQ and NASA-TLX results, each score of the ideal condition is small, and the



(a) The results of the SSQ.

(b) The results of the NASA-TLX.

Fig. 3: The box plots of questionnaire results of SSQ and NASA-TLX. Horizontal and vertical axes show names of conditions and answer values, respectively.

TABLE I: Results of the Steel-Dwass test of SSQ scores and NASA-TLX scores

| | ideal vs shake | ideal vs lag | ideal vs all | shake vs lag | shake vs all | lag vs all |
|---|---|---|---|---|---|---|
| $p_N$ | 0.21 | 0.63 | $0.05^{*}$ | 0.44 | 0.47 | 0.13 |
| $p_S$ | 0.33 | $0.07^{+}$ | 0.11 | 0.41 | 0.52 | 0.86 |

$(+ : p < .10, * : p < .05)$

scores of all are large, *i*.e., the workload and cybersickness intensify in the all condition. On the other hand, there are no large differences between shake, lag, and ideal conditions. The result suggests that the combination of spatial and temporal noise strengthens the burden imposed on participants.

The Steel-Dwass test was used to verify whether differences were found between the four conditions. Table I show the test results of SSQ score $p_S$ and NASA-TLX $p_N$. The results suggest a significant trend between the ideal and lag in SSQ scores. There was also a significant difference between ideal and all in the NASA-TLX scores.

## V. DISCUSSION

In this section, we discuss experimental results. From Tab. I, communication lags and stalls affect more strongly to the onset of cybersickness. In other words, it is suggested that cybersickness is caused by a lack of synchronization between the user's supposition of control input and the actual change of robot position.

Eunhee et al. [1] mention two experiments that examined the relationship between the intensity of the time delay of the images displayed on the HMD and the onset of cybersickness. One experiment showed that a stronger time delay resulted in stronger cybersickness, and the other experiment showed that an increase in the intensity of the time delay made no difference in the onset of cybersickness. In the latter experiment, authors hypothesized that the time delay applied to the vision was constant and that the participants could adapt even if the time delay was of an intensity that they could recognize, thus reducing the onset of cybersickness.

In our system, the image from the stereo monitor captured by the user's eyes moves in an unexpected direction of the user's prediction sometimes due to random stalls as well as a certain time delay as a communication lag. This behavior of the system prevents the user from adapting to the temporal noise, resulting in cybersickness.

From Tab. I, there was no significant trend for the workload to increase in comparison between the ideal and the factors alone, and a significant difference was observed between the ideal and all conditions. It is suggested that the combination of factors affects the increasing workload. When there is no noise or only some of the noise, the robot operation is easily estimated. In this situation, a participant does not have difficulty operating. On the other hand, when the robot operation is closer to the actual robot operation, *i*.e., combining multiple noises, it becomes intuitively difficult to operate the robot due to its unexpected behaviors.

Although the ability to rotate the monitor left and right by neck movements that we explained its presence during the instruction is implemented in our proposed system, some participants were reluctant to make neck movements. Thus, they took a strategy of aligning the front of the robot body in the direction they wanted to check. This result suggested that the monitor movement is not sophisticated for remote control tasks.

Fig. 4a and Fig. 4b show scatter plots of neck movements for a participant during the first session (shake) and the fourth session (ideal). From the figures, the participant's neck movements were more suppressed in the latter session than in the former. The SSQ questionnaires for both sessions show that the participants reported the onset of cybersickness in the former session, but not in the latter session.

Fig. 5a and Fig. 5b are time series data created for these two sessions (Fig. 4a and Fig. 4b) of data to compare the amount of robot rotating and neck movement. The horizontal axis is a timestamp[4], and the vertical axis is the amount of the moving average per 24 timestamps of the absolute value of the difference from the previous timestamp for the turning angles.

In Fig. 5a and Fig. 5b, the vertical axis shows the amount of smoothed robot turning or neck rotation angle, and the horizontal axis shows the time stamp (time axis). We calculated absolute value of angle difference in robot turning and in the yaw of the neck as

$$\Delta\theta_{\mathrm{R}}(t) = |\theta_{\mathrm{R}}(t) - \theta_{\mathrm{R}}(t-1)| \tag{3}$$

$$\Delta\theta_{\mathrm{H}}(t) = |\theta_{\mathrm{H}}(t) - \theta_{\mathrm{H}}(t-1)| \tag{4}$$

where $\theta_{\mathrm{R}}(t)$, $\theta_{\mathrm{H}}(t)$, $\Delta\theta_{\mathrm{R}}(t)$, and $\Delta\theta_{\mathrm{H}}(t)$ denote turning angle of the robot, yaw angle of the neck, change in robot turning angle, and change in the yaw angle of the neck, respectively. From these angle differences, the moving averages are calculated as

$$\mathrm{MA}_{\mathrm{R}}(t) = \frac{1}{24}\sum_{i=t-23}^{t} \Delta\theta_{\mathrm{R}}(i) \tag{5}$$

$$\mathrm{MA}_{\mathrm{H}}(t) = \frac{1}{24}\sum_{i=t-23}^{t} \Delta\theta_{\mathrm{H}}(i) \tag{6}$$

where $\mathrm{MA}_{\mathrm{robot}}(t)$ and $\mathrm{MA}_{\mathrm{head}}(t)$ represent the moving average of the change in robot turn and neck angle, respectively.

In Fig. 5a and Fig. 5b, the value of the change in neck angle $\mathrm{MA}_{\mathrm{H}}(t)$, is noticeably lower in the fourth session. Thus, it is suggested that in the first session, a participant used neck movements for seeing objects, but in the fourth session, the amount of neck movements were suppressed, *i*.e., a participant looks around without neck movement.

According to Tian et al. [17], cybersickness is caused by a discrepancy between stimuli to the vestibular sense, which controls one's posture and sense of balance, and visual information. Additionally, they suggest that vestibular stimuli from head movements are heavier-weighted signals to the brain than visual stimuli to the eyes and that these signals may cause cybersickness. In the system developed in this study, the vestibular sense of the user does not match the operation of the robot because the robot is operated by a keyboard interface. Therefore, a mismatch between vestibular sensation and vision is inevitable during the robot operation. By reducing neck movement, the participants reduced the number of signals emitted to the brain by vestibular stimulation, i.e. they reduced the information involved in integrating the senses, which may have reduced confusion in the brain.

## VI. CONCLUSIONS

In this study, we developed a Virtual Reality (VR) robot teleoperation system that incorporated spatial and temporal noises to investigate the relationship between robot operation and cybersickness. The system simulated slight vibrations caused by robot movement and introduced delays and stalls (communication lag) typical of actual network connections. We then compared the performance and effects of the noise-free operating system with the noise-affected system, focusing on their impacts on subjective cybersickness and workload.

We conducted the teleoperation experiment in a VR office environment, subjectively evaluating the onset of cybersickness and workload. The experimental results suggest that operation delays and stalls caused by communication lag are more influential in inducing cybersickness in a VR robot teleoperation system. Regarding the subjective evaluation of workload, the findings were inconsistent with the cybersickness results. However, the workload tended to increase when the two noise factors—robot shaking and communication lag—were combined. Additionally, we observed a compensatory behavioral tendency to mitigate the expression of cybersickness: participants suppressed neck movement and instead manipulated the robot's angle to survey the target area.

To better understand the biological mechanisms underlying cybersickness, it is crucial that future work considers additional factors, such as image quality and the realism of the simulator. Moreover, a key direction for our future projects involves comparing and evaluating VR and Augmented Reality (AR) systems in terms of the onset of cybersickness and operability, given that both are highly immersive systems.

## ACKNOWLEDGMENT

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## REFERENCES

[1] Hyun Taek Kim Eunhee Chang and Byounghyun Yoo. Virtual reality sickness: A review of causes and measurements. *International Journal of Human–Computer Interaction*, 36(17):1658–1682, 2020.

[2] Charith Fernando and Genki Sano. Future of telexistence® technology and its impact to the society. *Journal of the Robotics Society of Japan*, 36(10):682–686, 2018.

[3] K. Haga and N. Mizukami. Current status and future prospects of research on motion sickness. *The Japanese Journal of Ergonomics*, 42(3):71–79, 2006. [In Japanese].

[4] Sandra G Hart. Nasa-task load index (nasa-tlx); 20 years later. In *Proceedings of the human factors and ergonomics society annual meeting*, volume 50, pages 904–908. Sage publications Sage CA: Los Angeles, CA, 2006.

[5] Kaname HIRAYANAGI. A present state and perspective of studies on motion sickness. *The Japanese journal of ergonomics*, 42(3):200–211, 2006.

[6] Robert S Kennedy, Norman E Lane, Kevin S Berbaum, and Michael G Lilienthal. Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The international journal of aviation psychology*, 3(3):203–220, 1993.

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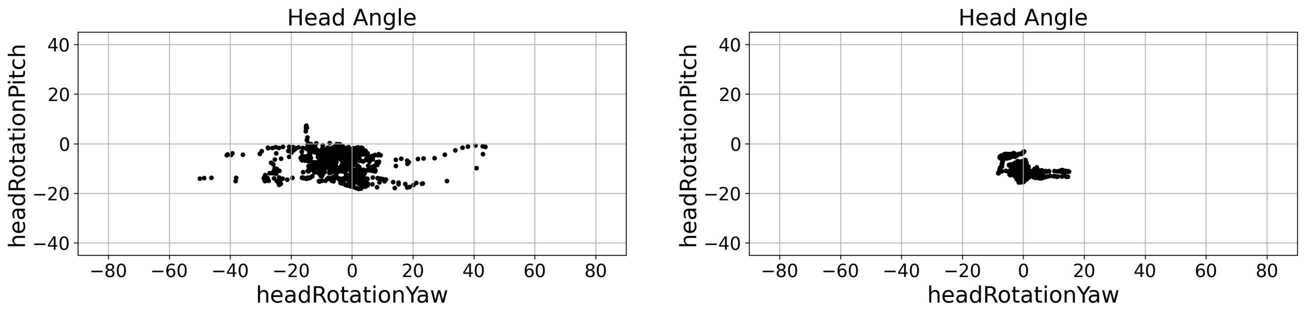
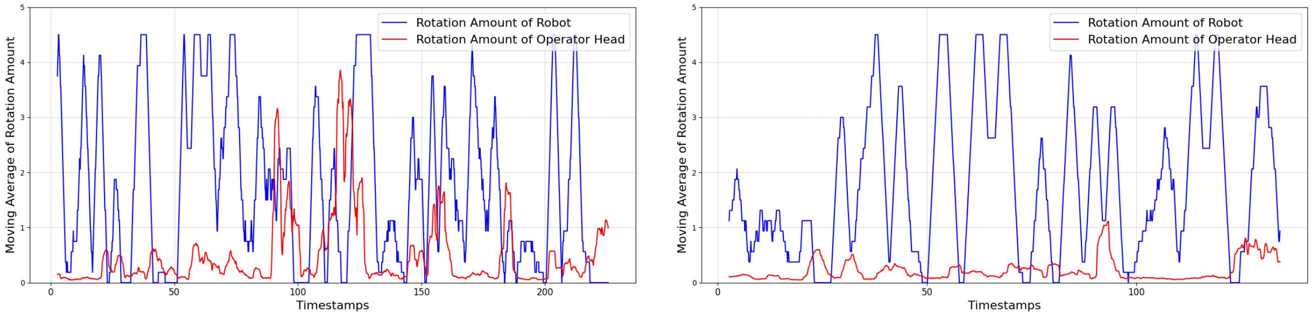
[4] the average number of seconds between the recorded timestamps was about 0.12 seconds.



(a) (b)

Fig. 4: The scatter plots of a participant's neck angle (yaw, pitch). Horizontal and vertical axes show yaw and pitch angles, respectively. (a) neck angle distribution for the participant's first session (SSQ score: 1127), (b) neck angle distribution for the participant's fourth session(SSQ score: 0)



(a) (b)

Fig. 5: Comparison of the amount of change in robot turning and neck angle in the first and fourth sessions. The horizontal and vertical axis indicates the time step and angle, respectively. The blue and red lines show the angles of the robot and the participant's neck. (a) the robot turning and neck angle during the first session, and (b) the robot turning and neck angle during the fourth session.

[7] Panagiotis Kourtesis, Josie Linnell, Rayaan Amir, Ferran Argelaguet, and Sarah E MacPherson. Cybersickness in virtual reality questionnaire (csq-vr): A validation and comparison against ssq and vrsq. In *Virtual Worlds*, volume 2, pages 16–35. MDPI, 2023.

[8] Joseph J LaViola Jr. A discussion of cybersickness in virtual environments. *ACM Sigchi Bulletin*, 32(1):47–56, 2000.

[9] Takurou Magaki and Michael Vallance. Developing an accessible evaluation method of vr cybersickness. In *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pages 1072–1073. IEEE, 2019.

[10] Makoto MISHINA and Toshiro ISHI. The subjective severity of simulator sickness induced by a driving simulator and its correlation with the psychophysiological measurement results. *The Japanese journal of ergonomics*, 44(5):279–289, 2008.

[11] Naoki MIURA, Hiroyasu UJIKE, Michiko OHKURA, and Masaomi KIMURA, editors. *Effects of sustained gaze in a direction on VR sickness*, Transactions of the Virtual Reality Society of Japan 24th (VRSJ2019). The Virtual Reality Society of Japan, September 2019.

[12] Volkan Sevinc and Mehmet Ilker Berkman. Psychometric evaluation of simulator sickness questionnaire and its variants as a measure of cybersickness in consumer virtual environments. *Applied ergonomics*, 82:102958, 2020.

[13] Volkan Sevinc and Mehmet Ilker Berkman. Psychometric evaluation of simulator sickness questionnaire and its variants as a measure of cybersickness in consumer virtual environments. *Applied ergonomics*, 82:102958, 2020.

[14] Patrick Stotko, Stefan Krumpen, Max Schwarz, Christian Lenz, Sven Behnke, Reinhard Klein, and Michael Weinmann. A vr system for immersive teleoperation and live exploration with a mobile robot. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 3630–3637. IEEE, 2019.

[15] Markku Suomalainen, Katherine J Mimnaugh, Israel Becerra, Eliezer Lozano, Rafael Murrieta-Cid, and Steven M LaValle. Comfort and sickness while virtually aboard an autonomous telepresence robot. In *International Conference on Virtual Reality and Mixed Reality*, pages 3–24. Springer, 2021.

[16] K. Takemoto, Y. Hatada, Y. Yamazaki, and K. Yoshifuji. Field experiment on remote customer service using the orihime telepresence robot for individuals with limited mobility. *Journal of Digital Practices*, 5(2):10–19, April 2024. [In Japanese].

[17] Nana Tian, Phil Lopes, and Ronan Boulic. A review of cybersickness in head-mounted displays: raising attention to individual susceptibility. *Virtual Reality*, 26(4):1409–1441, 2022.

[18] K. Vertanen. Nasa-tlx in html and javascript. https://www.keithv.com/software/nasatlx/. [Accessed: Jan. 7, 2025].

[19] Kai Virtanen, Heikki Mansikka, Helmiina Kontio, and Don Harris. Weight watchers: Nasa-tlx weights revisited. *TheoreTical issues in ergonomics science*, 23(6):725–748, 2022.

[20] Vstone Co., Ltd. Robot products. https://www.vstone.co.jp/products/robot.html. [Accessed: Jan. 11, 2025].

[21] Yutaka Nakamura Yuto Hattori and Yuya Okadome. Development of robot teleoperate system using neck motion to construct a data collection platform. pages 468–473, 2025.

[22] Sinan Zhang and Yumie Ono. A study of autonomic nerve indexes related to subjective discomfort during a virtual reality experience. *The Autonomic Nervous System*, 59(2):246–254, 2022.