

論文 / 著書情報
Article / Book Information

題目(和文)	時間遅延がある視線連動型移動窓に対する操作主体感覚
Title(English)	Sense of Agency at a Temporally Delayed Gaze-Contingent Display
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

(博士課程)
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論文要旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	機械 ライフエンジニア リング	系 コース	申請学位（専攻分野）： Academic Degree Requested	工学博 士 Doctor of	（ ing ） Engineer
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要旨（英文 800 語程度）

Thesis Summary (approx.800 English Words)

This dissertation, titled "Sense of Agency at a Temporally Delayed Gaze-Contingent Display," explores the mechanisms underlying the sense of agency when interacting with gaze-contingent displays, particularly under conditions of temporal delay from a user's action to the display's update. The research is presented in five chapters, each contributing to a comprehensive understanding of how temporal discrepancies between eye movements and interface updates affect the sense of agency, a concept critical in human-computer interaction (HCI).

The first chapter discusses the increasing prevalence of gaze-based HCI in daily life, facilitated by advancements in affordable eye-tracking technology. One key focus is on foveated rendering, a technique that reduces computational load by presenting high-resolution images only at the user's focal point, with peripheral areas shown in lower resolution. However, these systems inherently introduce temporal delays in visual feedback, which could disrupt the user's sense of agency. While extensive research exists on the sense of agency in limb-based interactions, systematic investigations into the sense of agency related to eye movements are scarce. This chapter establishes the dissertation's objective to fill this research gap by examining how delayed visual feedback in gaze-contingent displays impacts the sense of agency.

The second chapter presents a psychophysical experiment designed to measure the sense of agency in gaze-contingent interfaces. Participants engaged in a visual search task using a bi-resolutional display, where a high-resolution image was shown in the center of their vision, while a low-resolution image was shown in the peripheral areas. The findings are consistent with prior research on hand actions, indicating that the sense of agency is not confined to specific body parts but can extend to eye movement modalities as well. It was found that the sense of agency significantly diminished around a critical delay range of 200-300 ms. Importantly, the research demonstrated that changes in the sense of agency were observable through alterations in eye movement behavior, marking the first time the link between the sense of agency and eye movement planning has been empirically validated. The findings provide guidelines for designing delay-tolerant gaze-contingent displays, ensuring a seamless user experience even under challenging conditions in fields such as virtual reality, remote surgery, and teleoperation, where maintaining a strong sense of agency is crucial for effective interaction.

The third chapter extends the investigation to the effects of jittery delays, which are common in network-based HCI. The experiment mimicked these conditions by introducing temporal variability of 100 ms in the display's response to eye movements. The results indicated that jitter within the studied parameters had a minimal impact on the sense of agency, as the findings were consistent with those observed under constant delay conditions. This suggests that while delay consistency is important, jitter with a range of 100 ms does not significantly disrupt the user's perceived control over the interface.

The fourth chapter explores the neural correlates of the sense of agency using functional magnetic resonance imaging (fMRI). The study aimed to identify brain regions associated with processing delayed visual feedback in gaze-contingent displays. The analysis revealed significant activation in the right angular gyrus (rAG) in response to temporal delays, suggesting that this brain region plays a crucial role in mediating the sense of agency in gaze-based interactions. The findings imply that even for eye movements, which are not typically associated with direct manipulation of external

objects, the brain processes these actions as being self-initiated when the sense of agency is maintained.

The fifth chapter synthesizes the findings from the current three studies, highlighting the importance of the sense of agency in gaze-contingent HCI. The dissertation underscores that while the sense of agency is a well-established concept in limb-based interactions, it also extends to eye movements, which are increasingly used in modern eye-gaze HCI systems. The results have significant implications for the design of gaze-based interfaces, particularly in ensuring that visual feedback delays do not exceed critical thresholds that would disrupt the user's sense of agency. The chapter concludes by discussing the limitations of the study and proposing directions for future research, including the potential for applying these findings to improve user experience in virtual reality and remote operation systems.

This research provides a rare and valuable exploration of the sense of agency in the context of eye movements, a modality that is gaining prominence in HCI. By systematically investigating the effects of temporal delays and the neural correlates of the sense of agency, this dissertation contributes to both theoretical understanding and practical applications, including the first-person view.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note: Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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