An Interactive Robot Lecture System for Attention and Understanding Recovery

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Abstract: In lecturing, lecturers need to control the attention of learners to maintain while monitoring their learning states. We have claimed that a robot as lecturer can properly conduct nonverbal lecture behavior to control learners' attention and enhance their engagement compared with human lecturers. Although attention control is possible in shorter lectures, it would be more difficult for the robot to maintain learners' attention in a longer lecture. This prevents them from becoming aware of an important part of the lecture contents to understand. In this work, we have been developing an interactive robot lecture system that interacts with learners to recover their attention and understanding when they overlook the lecture contents. To recover learners' attention, the system first estimates their states of attention and understanding from their posture and gaze during lectures. Second, the system reconstructs a lecture scenario to generate an interactive lecture behavior, which combines non-verbal behavior about pause, walk, and repeat with paralanguage. The interactive behavior is implemented using a humanoid robot NAO. Third, the system provides questions about the slide contents for recovering their understanding when they lose their attention in spite of attention recovery.

Keywords: Interactive Robot Lecture, Attention Control, Understanding Recovery

1. Introduction

In e-learning and face-to-face lectures, lecturers need to control the attention of learners to attract their interests and to preserve their engagement. This also requires lecturers to properly use their nonverbal behavior involving gaze, gesture, and paralanguage. In longer lectures, in particular, lecturers should interact with learners using nonverbal behavior according to their learning states. Such interactive behavior allows lecturers to maintain learners' attention and engagement.

However, it is not easy even for experienced human lecturers to make appropriate use of nonverbal actions during the lecture or to keep track of learners' states. It is also difficult for learners to become aware of what they must pay attention to, thereby making them overlook an important part of the lecture contents. They often fail to follow the lecture and to understand the contents.

Towards resolving these problems, we have focused on nonverbal behavior for e-Learning lecture, and developed a robot lecture system in which the robot reconstructs nonverbal behavior of human lecturer, and presents the lecture contents with the reconstructed behavior (Ishino et al., 2022). The results of the case study with the system suggest that the robot lecture is more effective in attracting learners' attention and giving an understanding of the lecture contents rather than the video lecture and the lecture reproduction with the robot.

The robot lecture, on the other hand, could not recover learners' attention and understanding when they lose their attention and understanding (Kashihara et al., 2019 & Shimazaki et al., 2022). In this paper, we propose an interactive robot lecture system that recovers learners' attention and understanding during lecture.

2. Framework of Interactive Robot Lecture

Let us first explain the framework of the interactive robot lecture system we have been developing. In this work, we use a humanoid robot, NAO manufactured by SoftBank Robotics. NAO can walk, and perform nonverbal behavior such as gaze, pointing gesture, etc., and paralanguage such as voice volume, speed, intension, pause, etc., which are similar to those of human lecturers.

Figure 1 shows the framework of the system. The system conducts interactive robot lectures using three sub systems:

- Recoding system: Recording of lecture made by human lecturer,
- Sensing system: Learning states estimation, and
- Interaction system: Lecture scenario reconstruction and attention/understanding recovery.

A lecture scenario is defined as the contents of each slide, associated nonverbal behavior, verbal explanation, and the slide sequence that the lecturer considers when designing a lecture. The slide sequence is divided into several segments, each of which also consists of several slides, and represents a section/sub-section in the lecture contents. Each segment includes in-slide and between-slides questions used for recovering understanding of the corresponding slide contents.

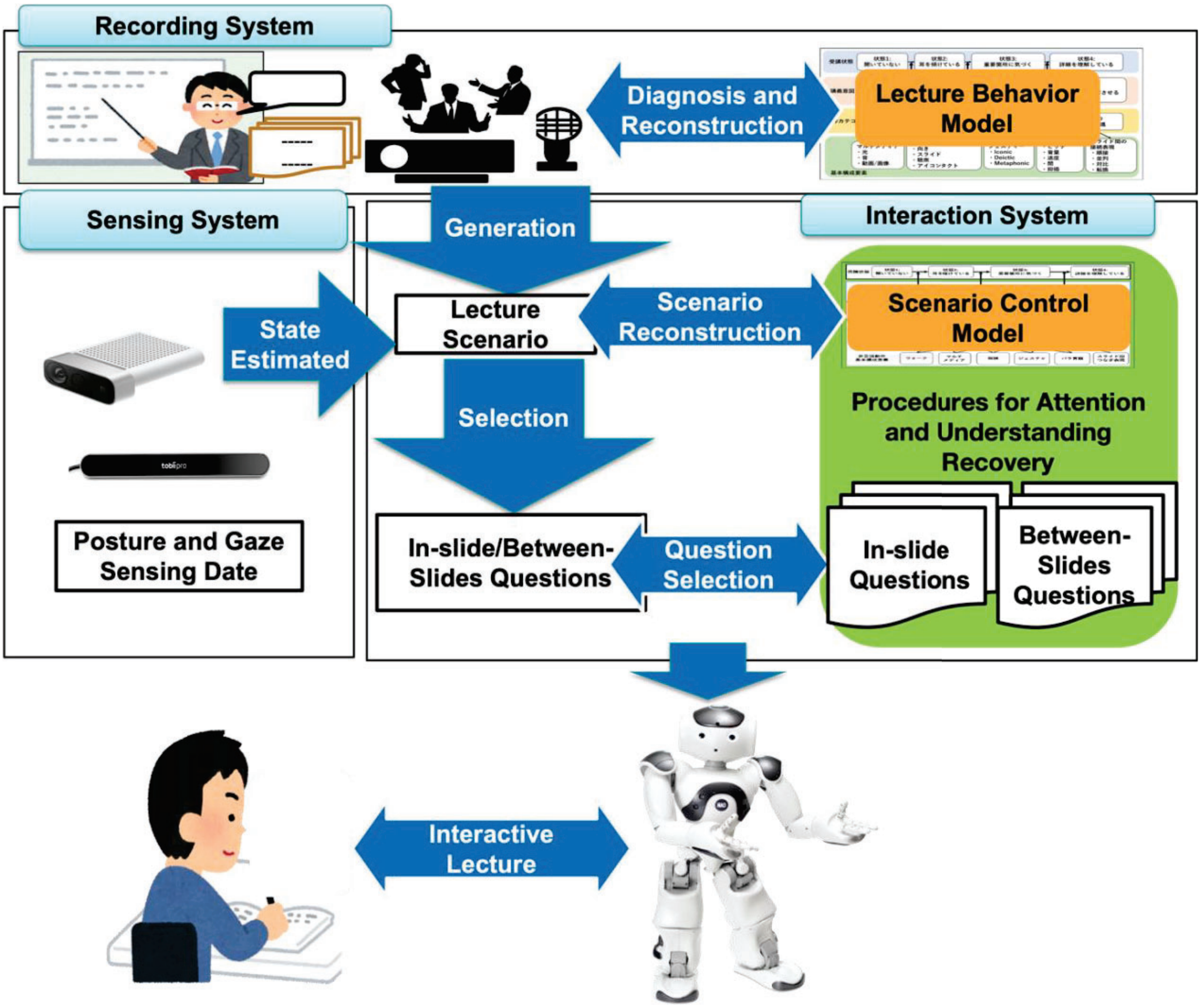
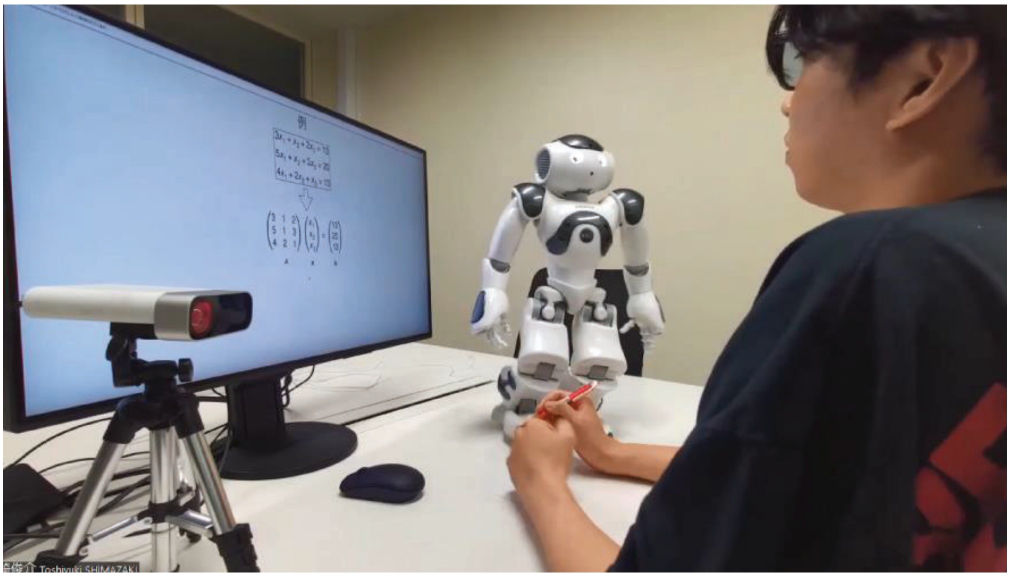
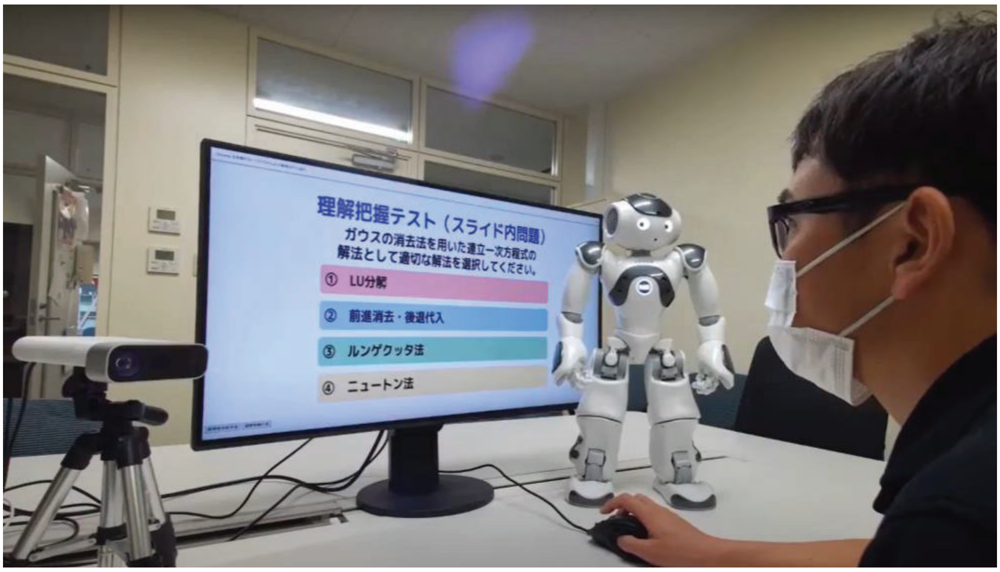


Figure 1. Framework of Interactive Robot Lecture.



(*a*) Robot Walking for Attention Recovery.



*(b)*Understanding Recovery with an In-slide Question.

Figure 2. Interactive Lecture for Attention and Understanding Recovery.

The recoding system records a human lecturer's lecture with Kinect to diagnose and reconstruct improper nonverbal behavior by means of a lecture behavior model we designed (Ishino et al., 2022). It then generates a lecture scenario. The segments of the lecture sequence and in-slide/between-slide questions are prepared in advance by the human lecturer.

The sensing system estimates learner’s states of attention to and understanding of each slide in the lecture sequence from their posture and gaze using Kinect and tobii pro nano.

The interaction system reconstructs the lecture scenario according to the estimated states to generate interactive lecture behavior for recovering their attention. In case the attention recovery fires more than once in one segment (in other words, their attention could not be recovered), in addition, the system provides them with in-slide/between-slides questions for recovering their understanding of the corresponding slide or the segment. The scenario reconstruction is done with the scenario control model and procedures for attention and understanding recovery (Shimazaki et al., 2023).

3. Sample Interaction

Figure 2 (a) demonstrates the robot walking to a learner. This shows an example of the attention recovery interaction. When the system estimates a learner looks away not to concentrate on a slide, in this example, NAO interrupts the lecture, and then walks towards him/her to ask if he/she would like it to repeat explanation of the slide contents. If he/she says yes, NAO explains the slide contents once again. Such interaction allows the robot to recover his/her attention.

Figure 2 (b) demonstrates the robot providing a learner with an in-slide question for recovering an understanding of a slide. This shows an example of the understanding recovery interaction. The understanding recovery fires when the attention recovery is consecutively failed in one segment of the lecture sequence. The number of times of the consecutive fails is defined by a human lecturer. If the number is defined as 2, NAO will fire the understanding recovery interaction after the attention recovery consecutively failed twice. In the understanding recovery interaction, NAO provides the learner with an in-slide or between-slides questions. These questions are 4-choice questions asking the contents in or the relationships between the slides where attention recovery has failed. If he/she answers all the questions correctly, NAO assumes that he/she understands the lecture contents, and restarts the lecture. If he/she makes a mistake, NAO explains the corresponding slide once again. Such interaction allows the robot to recover their understanding of the lecture.

4. Conclusion

In this work, we have been developing an interactive robot lecture system for learner's attention and understanding recovery. A preliminary case study has been conducted with high school participants to evaluate the accuracy of sensing data for learning state estimation and the interactive lecture with NAO. The results suggest that the learning state estimation using posture and gaze sensing data is similar to that of a human lecturer, and that the interaction with NAO contributes to maintaining learner's attention and recovering their understanding of the lecture contents.

In future, we will conduct a more detailed evaluation of the interactive robot lecture system with university students.

Acknowledgements

This work was supported in part by JSPS KAKENHI Grant Numbers 20H04294 and 23H03505.

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