協力行動インタラクティブシミュレータ RoCoCoの対話研究への応用

Cooperative Behavior Interactive Simulator RoCoCo for Dialogue Research

岩橋直人 [1] * 船越孝太郎 [2]
Naoto Iwahashi[1] Kotaro Funakoshi[2]

岡山県立大学 [1] [2] 東京工業大学
Okayama Prefectural University[1] Tokyo Institute of Technology[2]

Abstract: A software for research on cooperative behaviors, named RoCoCo, is introduced in this report. RoCoCo can perform interactive simulations of cooperative behaviors and provide analytical tools. It has a multiserver and multiclient configuration, and both humans and artificial intelligence can participate as agents. It supports versatile cooperative tasks such as *search*, *drive*, *joint transportation*, *rearranging multiple pieces of furniture*, and *ball play*. Here, the capabilities of RoCoCo are demonstrated, the results of the pilot experiments are presented, and the possible applications of RoCoCo in dialogue research are discussed.

1 Introduction

Cooperation is a fundamental human trait. Since the turn of the millennium, greater emphasis has been placed on a multifaceted understanding of cooperation that includes perspectives such as biological origins, socio-scientific properties, cognition and brain function, and mathematical or physical principles [1]. In an ongoing project on theories of cooperation [2], the theories and engineering applications of human-human, human-machine, and machine-machine cooperation have been comprehensively investigated.

In general, dialogue helps improve nonverbal cooperation, as well as verbal cooperation itself. In other words, dialogue can be explored from the perspective of cooperation (e.g. [3, 4, 5, 6]). Accordingly, a software platform called role coordinative cooperation (RoCoCo) was developed to facilitate research on cooperative behaviors. Its application to dialogue research are discussed in this report.

2 RoCoCo

2.1 General description

RoCoCo provides an interactive simulation of cooperative behaviors and mathematical analytical tools. Human participants control agents in a virtual space using a game controller to enable the agents to perform cooperative tasks. The resultant behavior can be analyzed for specific purposes. Figure 1 shows a participant operating RoCoCo.

Figure 1: Participants operating RoCoCo

With RoCoCo, participants are allowed to speak to each other to improve their behavior while performing cooperative tasks. Based on their interactions, the relationship between the dialogue and nonverbal cooperative tasks can be analyzed.

2.2 Cooperative task setting

The task setting comprises agents and objects. Certain types of agents and objects were prepared beforehand. Agent's action types include *movement*, *rotation*, *grip*, and *release*. Object types include *fixed*, *mobile*, and *inertial*. Specific tasks can be set by selecting appropriate agent's action and object types.

Examples of the available tasks are shown in Fig. 2. As specific tasks can be easily understood from the

*iwahashi@c.oka-pu.ac.jp, www-ail.c.oka-pu.ac.jp
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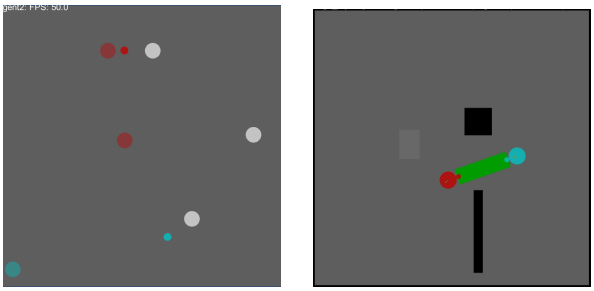
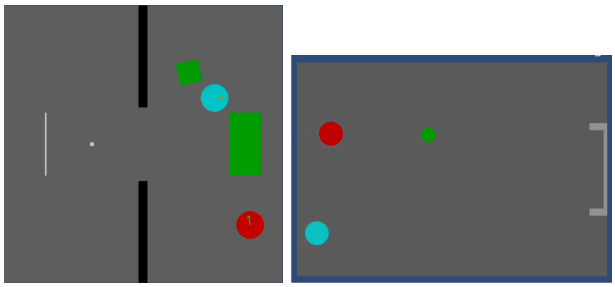
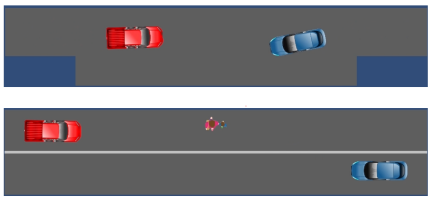


(a) Search (b) Joint transportation



(c) Rearranging multiple pieces of furniture (d) Ball play



(e) Drive

Figure 2: Task examples

figures, detailed explanations have been omitted.

2.3 Server-client configuration

RoCoCo has a client-server configuration, as shown in Fig. 3, and provides online multisession multiplayer connections. The session server provides a scene for a task and executes a physical simulation of the task, which can be located either locally or in the clouds. The player client serves as the interface between the server and the player, who can play as either human or artificial intelligence. Each figure in Fig. 2 shows the screen as seen by the human player client. Session managers monitor and control the progress of sessions. The system manager manages the connections between the session servers and player clients through a graphical interface as shown in Fig. 4 and helps conduct the subjective experiments efficiently.

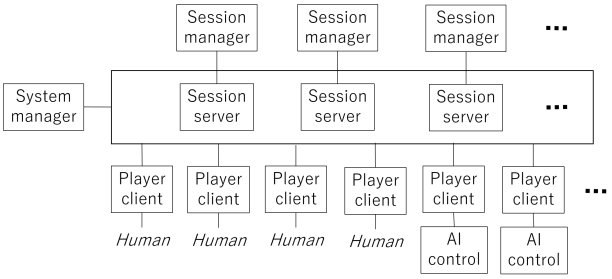


Figure 3: Server-client structure of RoCoCo

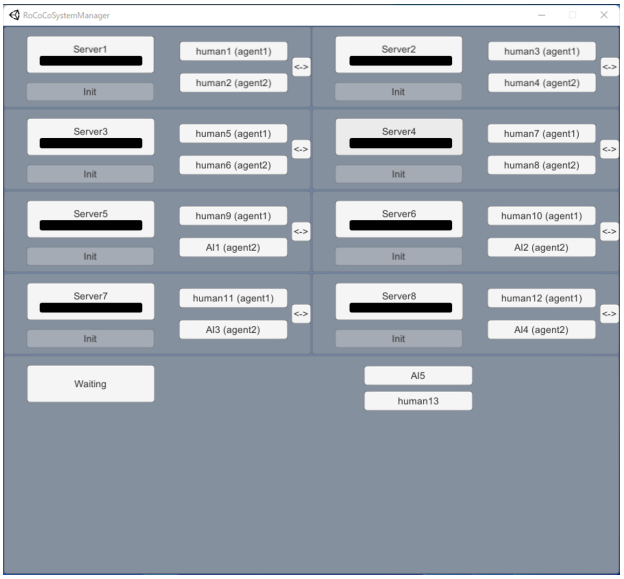


Figure 4: System manager's screen (Network information is masked.)

2.4 AI agent

An AI agent was developed as a RoCoCo player. In the subjective experiments, the AI agent passed the Turing test on the joint transportation task. Furthermore, the objective change in the characteristics of the AI agent's behaviors, such as action cost function, agent priority, prediction and inference setting, and other mutual belief settings, renders the cognitive experiments condition-controllable according to the purposes of the experiments.

3 Dialogue research

RoCoCo has tools for analyzing dialogue during cooperative tasks. The log of cooperative behavior with dialogue is stored in a video file and can be replayed, as shown in Fig. 5. In addition, it includes mathematical tools that can be used to analyze the characteristics of nonverbal behavior, dialogue, and their relationships from the perspectives of synchronization,

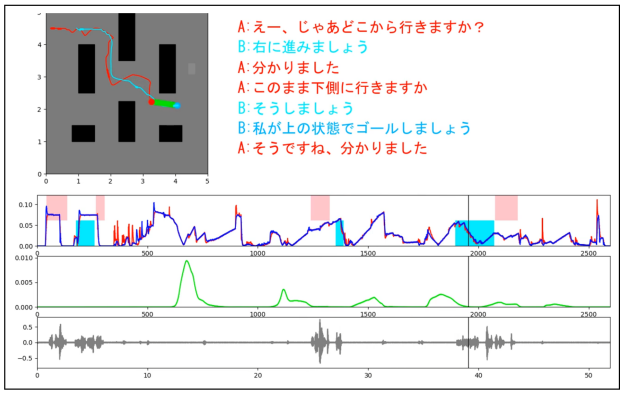


Figure 5: A log video

timing, planning, and repair.

One important feature to explore is the relationship between repair behavior and repair speech. For the analysis of this feature, RoCoCo provides a tool to measure nonverbal behavior inconsistency between cooperating agents. Another important feature is the relationship between the complexity of planning of nonverbal cooperation and dialogue. For this feature as well, RoCoCo provides a tool to continuously measure the complexity of dynamically changing cooperation situations. With RoCoCo, many other important features could be the subject of research.

4 Discussion

A software platform for research on cooperative behavior and dialogue, RoCoCo, was introduced in this report. We believe it will result in a new research paradigm and help discover the unexplored features of cooperation and dialogue. On the other hand, simulations in virtual space have the limitation that they cannot cope with the effects of various factors existing in real space. However, the ability to selectively simulate physical and psychological factors present in the real world could be an advantage over experiments conducted in real environments, where uncontrollable and undesirable factors cannot be eliminated.

From an engineering perspective, the dialogue research from the cooperation view would contribute the challenge of developing the effective spoken language interaction with robots [7, 8, 9], which is a social necessity. Furthermore, from a scientific perspective, RoCoCo would contribute the intersubjective research on cooperation and dialogue. Future work will include the comprehensive analysis of dialogue in nonverbal cooperation and the expansion of mathematical and cognitive tools for analyzing the dynamics of mutual beliefs in cooperation.

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