Sociable Dining Table: The Effectiveness of a "KonKon" Interface for Reciprocal Adaptation

Yuki Kado*, Takanori Kamoda†, Yuta Yoshiike‡, P. Ravindra De Silva§ and Michio Okada¶

Interactions and Communication Design Lab, Toyohashi University of Technology
Toyohashi, Aichi 441-8580, JAPAN
Email: [kado*, kamoda†, yoshiike‡, ravi§]@icd.tutkie.tut.ac.jp, and okada@tut.jp
Web http://www.icd.tutkie.tut.ac.jp/

Abstract—We developed a creatures-based social dining table that can communicate through a knocking sound, which in Japanese is pronounced as "KonKon." Our main focus was to create a minimal number of cues for proto-communication by establishing social interactions between a creature and a human. In particular, humans used the "KonKon" interface to communicate with a creature to demonstrate the social behaviors necessary to adapt to a person’s intentions. The creature used a mutual adaptation model for achieving a more ideal adaptation during the interactions. In the experimental results, we discuss the concept of the creature and indicate the effectiveness of the communication-protocol on the "KonKon" interface for mutual adaptation.

I. INTRODUCTION

The sociable robot concept is capable of increasing the quality of life for humans by providing assistance or support for their daily living and it’s efficacious to obtain an ubiquitous role from society [1][2]. In an attempt to comply with the above goal, it was important to invent a propitious social interface that is comfortable to use and interact with for untrained persons.

Hoffman [3] developed a robotic desk lamp (AUR) as a collaborative sociable creature for lighting assistance in a human-operated workspace. It was possible to engage the AUR using non-verbal communication and by changing its color light beam, which was adapted to the user’s anticipation by collaboration according to the task. In addition, a creature adapted to the location of user’s hand and its head direction was based on the user’s vocal interactions. As shown in these studies, sociable creatures can have a dexterous demeanor as a social partner for human users. It was also important to obtain potential user experiences and expectations on the social role of a robot in relation to their task or assistance.

In the present study we develop a sociable dining table which contains several robotic creatures (pot and dish) to serve as the user’s preferences. Our main focus is to create a minimal number of social cues for proto-communication in order to establish social interactions between a creature and a human in order to fulfill their goals.

II. SOCIALEIBLE DINING TABLE (SDT)

The user can assert his intentions through the KonKon interface (e.g., knocking knuckles on the surface of a table), which can be considered as a minimal social cue to express a user’s intention to a creature (pot and dish). A person’s intentions and ability to adapt are different depending on a person’s personality. In this sense, we believed that a user prefers to interact with creatures using their own individual interacting patterns, since creatures need to use a personalized adaption while they interact with different users.

Therefore, the mutual adaptation model capitalizes on Actor-Critic architectures with a temporal difference learning method. The creature has four actions (move to right, left, straight, and back), and the actor-critic architecture uses a number of knocking sounds to decide the action of the creature. Based on ascertaining the creature, the user can convey his intentions by a number of knocking sounds while looking at the creature adaption (motion path). The creature is capable of performing mutually adaptive learning through the actor-critic model (TD model) in real time to reach the user’s goal or intentions.

III. SYSTEM DESIGN FOR SDT

The top of the SDT has a webcam to detect the position of creatures and that information is also used to estimate its rotation angle (Figure 2). Four microphones are fixed on the table and sound source localization with weighted regression is used to estimate the direction of the knocking sound. All
of these devices are connected to a host computer which is located under the table. In the current setup, the SDT has two sociable creatures which communicate with the host computer through Wi-Fi. The creature is built with a one-chip microcomputer (AVR ATMega128) and is connected with servo motors, batteries, and five photo-reflector sensors. It can move around a table using the servo motors with positing information from the host computer (i.e., through webcam and image processing). Photo-reflector sensors are utilized to detect the boundary of the table and are also useful to detect creature take off by the user.

IV. EXPERIMENTAL SETUP

We evaluate the performance of sociable creatures with a mutual adaption model for a single user while interacting with the SDT. Fourteen students participated as the subjects of this experiment. Each of the subjects was engaged in two trials with the SDT. In the first trial, each participant has to move the creature into five decided places on the table (start, 1, 2, 3, goal) utilizing a knocking sound. In the initial trial, the creature starts to move in a straight direction and the user can change its path using his knocking sound to fetch the desired points on the table. During the interaction, the creature attempted to construct a precise mutual adaption policy (parameters of TD model) which dominant the human intentions.

In the second trial, we changed the place of the former points on the table and the user must guide the creature into newly establish points (start, 1, 2, 3, goal) on the table. The sociable creature uses the mutual adaption model (which is constructed in previous trial) to conceive of the human intentions to archive the user’s goal. Additionally, the sociable creature is capable of adapting to and learning the user’s rewards through the knocking sounds during the interactions.

V. PERFORMANCES OF MUTUAL ADAPTATIONS MODEL

We defined the $\phi$ as the angle between the creature’s front direction and a desired point on the table. It helps to evaluate the behavior of creatures (mutual adaption) based on the user’s intention (knock sound). The ratio of the physical relationship between the creature and a desired point is estimated according to the following conditions: for straight motion $\frac{90-\phi}{90}$ (if $\phi < 90$) or 0 (if $\phi \geq 90$), rotation $\frac{\phi}{90}$ (if $\phi < 90$) or $\frac{180-\phi}{90}$ (if $\phi \geq 90$), and back motion 0 (if $\phi < 90$) or $\frac{\phi-90}{90}$ (if $\phi \geq 90$). If the creature moves toward the desired points ($\phi$ angle is small) then the above defined ratio values increase. The Figure 3 shows the average ratio values (mutual adaption) for each of the users during the experiments. In the initial trial we had a low average ratio when compared to the second trial. The reason for this is that during the first trial the creature tried to adapt to the user’s intention, and in second trial most of the users obtained higher ratio values. This implies that creature made a sustained adaption with the user to reach their goal.

VI. CONCLUSION & FUTURE WORK

We proposed a creatures-based sociable dining table that can communicate with minimal proto-communication cues. We showed that a knocking sound is adequate for building a user’s mutual adaption model accurately as shown by the results of the experiment. As future work, we would like to extend the mutual adaption model so that the creature behaviors can interact and engage with many users simultaneously.

ACKNOWLEDGMENTS

This research has been supported by both Grant-in-Aid for scientific research of KIBAN-B(21300083) and HOUGA (19650044) from the Japan Society for the Promotion of science (JSPS).

REFERENCES