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Active interaction utilizing micro mobile robot and on-line data gathering for experiments in cricket pheromone behavior

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HIGHLIGHTS

- A novel approach of interaction experiment with cricket.
- Development of a prototype system for active interaction utilizing an operated mobile robot.
- On-line gathering experimental data of the interaction between cricket and mobile robot.

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ABSTRACT

This paper describes about a prototype system for active interaction experiment to a cricket by utilizing an operated micro mobile robot. It is also able to measure/collect behavior data of the cricket on-line. The behavior selection of the cricket (*Gryllus bimaculatus*) is influenced by the experience or the context in living environment. In our current research, we are trying to investigate neuronal mechanisms underlying adaptive behavior switching of the cricket based on individual interactions. However in conventional biological experiments, the conditions are not maneuverable intentionally. Therefore, we are developing an integrated system for conducting active interaction experiments and gathering behavior data related to the effect of interactions. The prototype consists of a micro mobile robot as a physical interaction agent, a camera and a microphone and a computer. The computer is for commanding the robot by the operator's input. It also works for recording the data of a video sequence, on-line motion tracking and the audio during the experiment. Interaction experiments with the cricket utilizing the prototype system were done. From the results, we could confirm it works well especially for maneuvering experimental conditions and on-line experimental data gathering.

1. Introduction

Animals on this planet select their own behavior adaptively based in part according to their environment in real time. This is attributable to neural circuit network plasticity. Therefore, many studies have sought to clarify high-order motion control in animals through behavioral observation and physiological analysis. Generally, human beings have approximately 100 billion neurons in their huge brains, whereas insects have approximately one million neurons in their whole nervous systems as a micro brain. In order to understand how to select the behavior adaptively, it would be better to investigate a behavior selection mechanism based on a simple nervous system. Therefore, in our current research, for understanding adaptive behavior selection as a dynamic system, we are focusing on insects, in which the relationship between neuronal activities and selected behavior is easy to observe and investigate them. For a typical example, Webb [1,2] has conducted significant works on modeling the neural system of an insect. The works showed a sensory-motor system based on the knowledge of the insect's behavior and response.

Crickets (*Gryllus bimaculatus*) (Fig. 1) show behavior switching based on the interactions between individuals and are representative of pheromone behavior in insects [3]. Pheromone behavior emerges when animals detect a particular pheromone. For example, in behavior selection for the fighting behavior of crickets (Fig. 2), nitric oxide (NO) is thought to function as a neuromodulator for extracting a specific behavior program from polymorphic circuits in the brain and that the NO/cyclic guanosine monophosphate (cGMP) cascade plays an important role [4]. Several research results show that some kinds of biogenic amine

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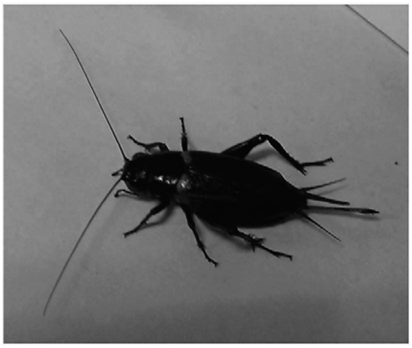

Fig. 1. Female cricket: *Gryllus bimaculatus*.

(octopamine (OA), serotonin (5-HT), *etc*) play important roles to adjust the aggressiveness or sensory efficacy in the insect's nucleuses. Also, based on these internal responses, it is well known that the cricket modified its own behavior selection adaptively regarding its fighting behavior [5,6]. The cricket also changes the tendency of behavior selection based on its own experiences or context in the other situations [7].

However, it is still unclear how spatio-temporally independent/fragmented knowledge obtained by neurophysiological/ethological research can be integrated as a dynamic system. We consider it is important to alternately repeat synthetic and analytical approaches in which a hypothetical model is simulated based on physiological knowledge and, to verify the results obtained in further physiological experiments [8]. Thus, for understanding adaptive behavior selection mechanism as a dynamic system, we are taking a synthetic approach to compose a dynamic model by connecting biological properties with some hypotheses (Fig. 3) [9]. We call it a synthetic neuroethological approach. Thus, we constructed an adaptive behavior selection model in cricket's fighting behavior inspired by the behavior of the neuromodulator and the substrates in the micro brain [10]. Moreover, we also extended such a model with some hypotheses from system synthesis aspect [11]. It was verified that such a modeling research result contributed to the adaptive cooperation algorithm of the artifacts/robots [12,13].

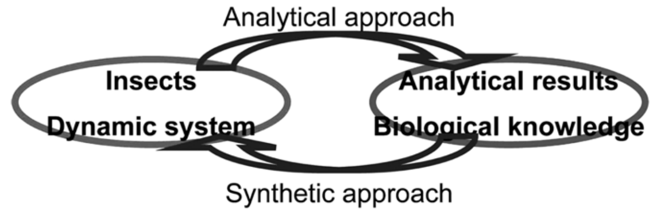

Fig. 3. Approach of our current research for understanding adaptive behavior selection mechanism.

Moreover, in order to gather data or information for a better understanding of dynamic adaptability of crickets, we started an interactive experiment using a micro mobile robot [14,15]. This is an interesting and novel trial related to active interaction with the cricket. For more progress to understand adaptability of the cricket, we are intending to set the experimental condition maneuverable system for gathering additional data related to pheromone behaviors. Therefore, we developed a system for an active interaction experiment with the cricket and are gathering experimental data of the cricket's pheromone behavior on-line. This paper describes a developed prototype and reports several basic experimental results utilizing the system.

This paper is organized as follows. Section 2 introduces the cricket and our previous works for understanding its adaptive behavior. Section 3 describes our prototype system for active interaction and on-line experimental data gathering. Section 4 also describes the experimental results utilizing our prototype system. Finally, Section 5 presents our conclusions.

2. Cricket: *Gryllus bimaculatus* and previous works

Although crickets (Fig. 1) do not form swarms, but rather are solitary in their activities, they do show some social adjustment behaviors. A pheromone communication between individuals is generally the basis of such behavior adjustments of the insects [7]. While pheromone behaviors of insects were once considered to be "hard-wired" and specific pheromones were thought to cause specific behavior, it is becoming clear that the insect pheromone behavior involves plasticity by modification.

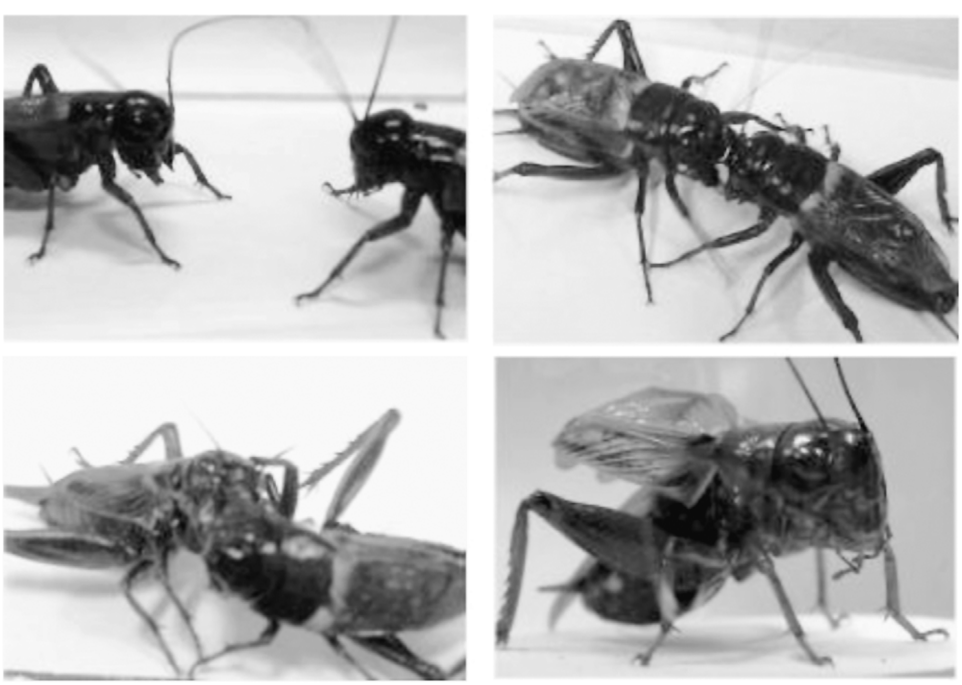

Fig. 2. Snapshots of fighting behaviors between male crickets.