R&D Item

5. Expansion of Control Targets and Application Field for Network Intelligence System

Progress until FY2024

1. Outline of the project

This R&D theme aims to apply the new targets as agents for the network intelligence system, instead of the small robot swarm which has been developed in R&D theme 1 to 3. These realize advanced tasks such as exploration robustly and continuously by controlling multiple small robots of the same type with limited self-control and guidance functions and low aircraft control performance as a network intelligence system. In particular, the lower-layer AI (swarm intelligence) assumes the low controllability and accuracy of small robots, and considers a control method to form a swarm without considering the location or control state of each robot. There is no need to consider the placement and control state of each individual robot, and the control parameters held by the robot are limited, ensuring the stability of the entire system regardless of the individual situation. In other words, it is characterized by providing a control method that does not make the upper-layer AI aware of individuals. Furthermore, the lower-layer and higher-layer AI assume that there is a large ambiguity in the location and environmental information obtained from the robot, and realizes handling of ambiguous data and robust operation. We will consider the expansion of this network intelligence system, especially the system provided by the lower-layer AI, and the control framework and characteristics to control targets other than lunar and planetary exploration robots, and collaboration schemes with various robot systems, and explore the possibility of application development mainly on the ground, which is closer to people's lives. We will also discuss various issues that arise during the study and aim to resolve them as necessary.

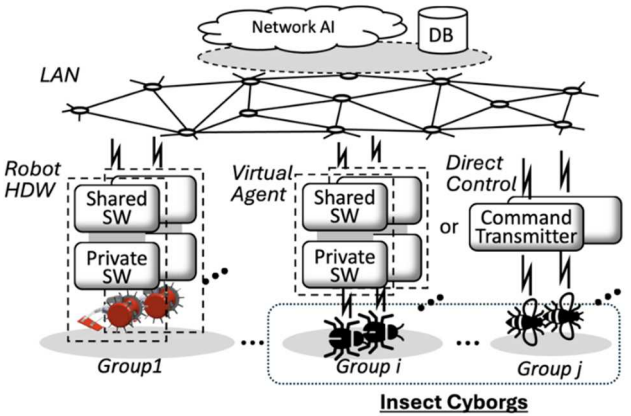
In this theme, we have selected cyborgized organisms (called "insect cyborgs" as we mainly deal with insects) as new control targets, which do not require control of the machine itself but are theoretically difficult to control, and will consider how to achieve control from a network intelligence system and solving problems with cyborg technology.

2. Outcome so far

We conducted a series of research and development from basic design to verification, focusing on the complex elements of insect cyborg control, behavioral analysis, and collaboration with robots. We selected organisms suitable for terrestrial use, mainly the Madagascar cockroach, and optimized the control stimuli, and collected behavioral data in a surface environment close to the real environment. Based on the acquired IMU data, we constructed a machine learning model (random forest) to classify the surface topography, achieving high classification accuracy. We also developed a real-time ground mapping system using five insect cyborgs, and successfully demonstrated that it covered more than half of a 3 m x 3 m search area within an hour. In addition, we achieved remarkable results in optimizing the control protocol, such as disabling the sensory organs (compound eyes and monocular eyes) to improve navigation accuracy, significantly shortening both the navigation distance and time.

3. Future plans

We will advance research and development by building the foundations for elemental technologies (protocols for reducing stimulation frequency, optimization of robot travel routes, and collaborative control of cyborg groups).



Concep of the insect cyborg

JST Japan Science and Technology Agency