R&D Item

2. Individual and Collective Evolutionary Functions

Progress until FY2024

1. Outline of the project

This R&D theme is the functions, systems, networks to achieve the cooperative activities of the swarm robot. Therefore, we are researching and developing "evolution of robot individuals and co-evolution of robot swarm".

To evolute the functions of robot individuals, the robot design that can be upgraded the task functions will be needed. Moreover, for robot evolute operationally through making swarms, the design that task functions have to be shared across the robot individuals is needed. Therefore, minimum fundamental task functions to operate robot individual will be designed on hardware ROM as low granularity task module. Then, expanding or adding functions will be extended as software on RAM. More complex and difficult task will be achieved as high granularity tasks through common memory virtual connection of low granularity module. The tasks on robot will be generated and upgraded through telecommunication, and robot individuals are always being changed, grew and evolved. these will be integrated with R&D theme 1's Network Intelligence, then according to the environment of robot operations and their job, they will go to evolve through selecting modules and connections autonomously.

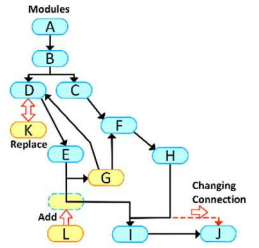
Furthermore, the modules evolvedautonomously in each robot will be able to be shared through the telecommunication network. As abobe, a certain robot individual's upgrading will be shared on other one, this will be similar shared with the swarm. This means that inserting or replacement new robot into swarm are similar with metabolic with the entire swarm robot. Therefore, functions of the entire swarm will continue to be evolved and grown autonomously.

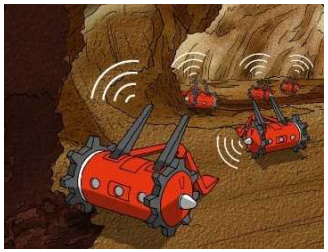
Eventually, we will integrate this R&D theme 2 with R&D theme 1 and 3, then achieve that the robot swarm will explore autonomously and build the activity bases.

2. Outcome so far

We have developed the low granularity functional module as basic unit in the evolutional functions of robot individuals. Bundling the several modules, on Field Programmable Gate Array, we have achieved configuring the high granularity modules, and to insert, delete and switch the modules. Moreover, to control these modules, we have developed the management and operation software to configure and change each task. We have confirmed to achieve to configure 3 high granularity module tasks with 10 connection-sized from around 30 low granularity modules. Then we have also achieved the virtual connection between modules using each task and data control of the entire task. Moreover, we have confirmed the functions and operational speed of configured tasks from gathering and analyzing of the input-output data and the operational information of data flow on connected and shared memories.

Furthermore, we have clarified the basic design through the discussion of the inside architecture of the control devices to evolve the task functions. Based on these results, we have designed basically and experiment initially the telecommunication system of the functional common network.





3. Future plans

We will next make the evolutionally control devices to make high granularity tasks from low granularity modules. Then we will implement these devices into the robot individuals and achieve the evolution functions on each robot.

To achieve swarm's co-evolution function, we will develop communication devices for the function common network. Through this network, evolution function of the robot individual will be shared, and these will be able to configure the tasks including the common modules of each robot. Then, communication devices for the common network and the control devices for the evolution functions will be developed. the control devices will be next upgrade for Space specifications、 be implemented for the robot, and be tested for integrated operations. Moreover, this control device will be extended on the common network, and these will achieve the cooperative behaviors multiple robots. Furthermore, radio navigation system will be developed for lunar exploration mission. The marker function to point the center of the swarm and data communication system based on UWB radio will be achieved.

To achieve these functions by the swarm autonomous, the network intelligence has to learn recurrently as AI. Then, the obtaining of the learning data from the swarm's common network will be able to make each robot learn from other robot's data. These will lead to the result that robots will learn recurrently each other, and the swarm will be able to be co-evolved. Then, fog-computing and grid-computing will be available, and the intelligence implemented distributed in each robot will be able to be used. This will develop as an operational infrastructure of network intelligence in future.