論 文 の 要 旨

題 目　Collective behavior generation and analysis for an evolutionary swarm robotics system
(進化的スワームロボティクスシステムにおける群れ行動の生成と解析)

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Swarm robotics (SR) is a novel approach inspired by the observation of social insects, such as ants and wasps. These examples of social insects show that simple individuals can successfully accomplish difficult tasks when they coordinate as a group. This kind of system-level behavior, which appears to be robust, scalable and flexible, is impressive to researchers working on robotics. Similarly to these social insects, SR systems (SRSs) are expected to accomplish tasks beyond the capabilities of a single robot. By definition, an SRS comprises a number of relatively simple and typically homogeneous robots that a desired collective behavior emerges from the local interactions among the agents and between the agents and the environment, similar to the social insects. In this research field, there are two fundamental problems: the hot topic design problem and the undeveloped area analysis problem. These two problems consist of defining the appropriate individual rules that will lead to a certain global pattern and analyzing the generated collective behavior.

In this thesis, we proposed a design methodology: a simulate robot controller was evolved by a recurrent artificial neural network with the covariance matrix adaptation evolution strategy (CMA-NeuroES) for conducting incremental artificial evolution. Cooperative food foraging is conducted for our proposed controller as one of the most complex simulation applications. Since a high level of robustness is expected in a swarm robotics system, several tests are conducted to prove that the incremental artificial evolution with CMA-NeuroES generates the most robust robot controller among the ones tested in simulated experiments. On the other hand, we also applied an analysis method inspired from the field of complex networks. A network associated with a SRS of which is drawn by assuming that nodes are robots and links are informational connections with two nearest robots after we generating the collective behavior of a cooperative food foraging problem. This method makes it possible for us to extract the subgroups in a robotic swarm. Applying this method with the concept of behavioral sequence inspired from ethology, we can successfully observe task allocation of a cooperative food foraging problem.