A Simulation Study on Adaptive Behavior of Fish Schools under Environmental Variation

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1. MODELS OF FISH SCHOOL

In this paper, as an example of ecological systems, fish school models are presented for studying the adaptability to environmental variations. The models have their own characteristics such as cooperation (cooperative or repulsive), and diversity (homogeneous or heterogeneous) which is represented in the model parameters obtained from water tank experiments. According to the model parameters, the following four kinds of fish school models are proposed.

Model I: Cooperative homogeneous model (fish school of Bitterling).

Model II: Repulsive heterogeneous model (fish school of Tilapia).

Model III: Repulsive homogeneous model in which the cooperation characteristics approaches to that of Model II and the diversity characteristics approaches to that of Model I.

Model IV: Cooperative heterogeneous model in which the cooperation characteristics approaches to that of Model I and the diversity characteristics approaches to that of Model II.

Various simulations are carried out by using the respective models under an environment designed by setting an obstacle in the behavior space. The adaptive behavior to environmental variations is examined based on the simulation results. The relationship between adaptability and system characteristics is discussed.

2. SIMULATION RESULTS

The number of individuals in a fish school is chosen as $N_f = 20$ in the simulations. A box-shaped trap and a leading wall are set in the behavior space to give a fish school an environmental variation. The trap has three sides of walls and one side of an entrance from which fish can enter and go out freely. The quantity M of information exchange among the individuals in the school is changed from 3 to 19 in the simulations. The total time of simulation is set to be 300 seconds. $\bar{T}_e$ expresses the average value of the escaping time of a fish school from the trap. Figure 1 shows the variation of $\bar{T}_e$ for four models with the quantity M of information exchange.

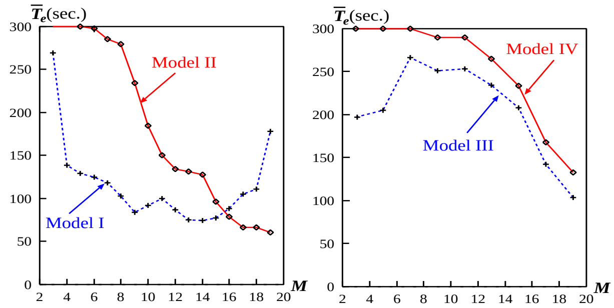

Figure 1: Average values of escaping time for four kinds of models

It is found from Figure 1 that $\bar{T}_e$ reduces with M increasing for all models except Model I. For Model I, the smallest value of $\bar{T}_e$ is obtained when M takes a middle value. This indicates that if a system has too high cooperation and too low diversity such as Model I, then it needs a proper control quantity $M \cong N_f/2$ to increase its diversity and to decrease its cooperation. On the other hand, if a system has too low cooperation or too high diversity such as Model II $\sim$ Model IV, then it needs a proper control quantity $M \cong N_f - 1$ to increase its cooperation or to decrease its diversity. Thus the adaptability of systems to the environmental variations is increased.

The idea that the optimum quantity of information exchange depends on the characteristics of a school has been applied to the optimization of a scheduling problem on parallel machines[1].

REFERENCE

1) Y.Tian et al.: *Proc. of 26th SICE Intelligent System Symp.*, pp.133-138 (in Japanese).