4P-01 Cooperative Tactics Acquisition Using GP

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1 Introduction

As a method for multi-agent simultaneous learning, Genetic Programming has been applying to the research of cooperative and competitive behaviors acquisition[1]. We propose the "Agent Relationship Evaluation(ARE)" using GP at the tactics acquisition for the agents of a simplified soccer game. "ARE" makes it possible mutual agents explicitly evaluate each other, we confirmed the acquisition of cooperative behaviors by using "ARE"[2]. In this paper, we report the "ARE method" in detail.

2 "ARE" Method

Existing Co-evolution was the mutually evolving method by dividing into prey and predator under the identical space, it has been aiming for the emergence of behaviors by competing with opposite agent. On the other hand, "ARE" is also descended from the method of Co-evolution, but it is different in that the agents of same kind explicitly evaluate other agent. We named this evaluation method "ARE method". At "ARE method", the evaluation criterion between agents is included in GP as the function(program) within tactic individual.

2.1 Single Tactics Acquisition

To realize "ARE method", we inserted the "*eval_mate* function" as a node of GP. This function evaluates the tactical individual of other agent, that evaluated value is calculated with eq.(1).

$$\begin{aligned}&(Evaluated\ Value)\\&=\sum(Evaluated\ Value\ of\ each\ function)\\&\quad+(Goal\ Reward)\end{aligned}\tag{1}$$

Next, we explain about the realization of "ARE" in GP. Fig.1 shows the example of evaluating tactical individual using the "*eval_mate* function".

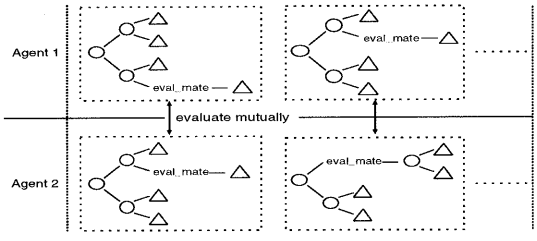


Fig. 1: "ARE" with "*eval_mate* function"

In the "ARE method" using the "*eval_mate* function", the following processes are repeated till the finish condition is filled, and the number of repeat process times equal the number of tactical individual at a generation.

1: Carry out simultaneously the tactical individual of same ranking, the agent get the evaluated value

2: Sort the population according to evaluated value

3: Do the genetic operation, Create new generation

At "ARE method", the only one "*eval_mate* function" is always inserted in tactical individual, and when the behavior of each tactical individual finished, the "*eval_mate* function" gives the tactical individual of other agent the evaluated value. Therefore mutual agent can explicitly evaluate the tactical individual of other agent compared with the own created tactical individual. For the one cooperative behavior that the human wants to acquire, if the "*eval_mate* function" is produced so as to give the high evaluated value, the tactical individual of the agent can evaluate synchronously the tactical individual of other agent. As a result, "ARE method" makes it possible to acquire the single cooperative behavior.

2.2 Plural Tactics Emergence

The evaluation of "*eval_mate* function" deals with only the evaluation of single tactical individual. And, only if the human formed beforehand to the agent the behavior to want to acquire by the "*eval_mate* function", the agents could acquire the cooperative behavir. So we extended the "*eval_mate* function" to the "*eval_mate*[#] function". We proposed that only if the # of mutual individual correspond, the "*eval_mate*[#] function" can evaluate the tactical individual, as the "*eval_mate* function". As a result, only higher behavior of mutual evaluated value survive, and the one cooperative tactics emerge for each #. Fig.2 shows the notion of the "*eval_mate*[#] function".

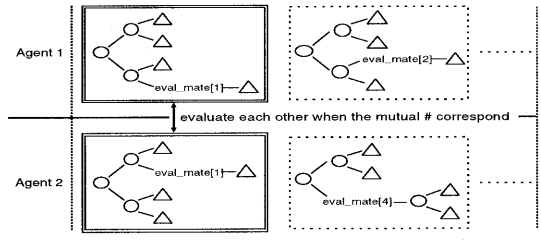


Fig. 2: "ARE" with "*eval_mate*[#] function"

If the agent1 and agent2 decide separately the number # of "*eval_mate*[#] function", when each agent takes action simultaneously, the probability that the number # of agent1 and agent2 is the same is low, therefore the learning speed will fall. So we attempted to improve the learning speed by fitting the number # of agent2 to the number # of agent1.

The process of the "*eval_mate*[#] function".

1: Fit # of agent2 to the # of agent1 in the tactical individual of same ranking

2: Carry out simultaneously the tactical individual, the agent get the evaluated value

3: Sort the population according to evaluated value

4: Do the genetic operation, Create new generation

By using the "*eval_mate*[#] function", without forming to the mutual agent the tactics that the human wants to acquire, each agent can evaluate the mutual tactics individually that corresponded to the # of function.

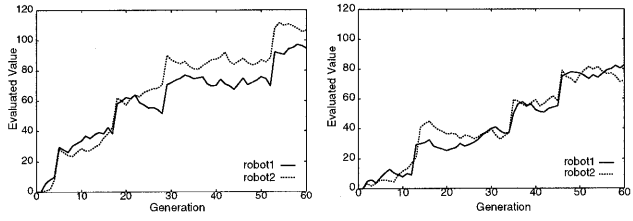
3 Experiment

We applied "ARE" method to the tactical individual population of two real robots[1], and we carried out two experiments, the acquisition of single cooperative tactics and the emergence of plural tactics, at $90cm \times 70cm$ soccer field. In the single cooperative tactics acquisition, we aimed at the acquisition of the pass behavior. As only when the mate of agent kicked a ball, the agent explicitly evaluate each other, we shaped the "*eval_mate* function". The parameters in GP here are: the size of each population is 50, the number of generations is 60. In the plural tactics emergence, the # of the "*eval_mate*[#] function" was set from 1 to 5, so we aimed at the tactics acquisition of 5 kinds at the one learning. Here, the population size is 60, the number of generations is 50.

4 Experiment Results

4.1 Single Tactics Acquisition

By experiment, we confirmed the acquisition of the pass behavior. The comparison results using "ARE" and without "ARE" are shown in Fig.3. Fig.3 shows the learning efficiency of using "ARE" is better than not using "ARE".



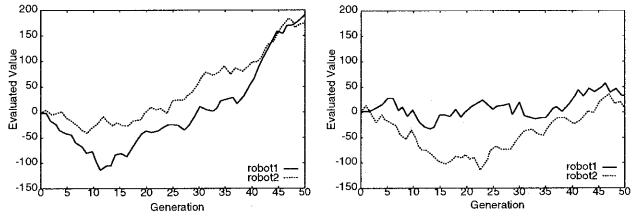
(a) With "ARE" (b) Without "ARE"

Fig. 3: The average evaluated value in each agent

[1]We used the Khepera Robot

4.2 Plural Tactics Emergence

Fig.4 shows the average evaluated value of tactic individuals in each agent. It shows the method with "ARE" has better learning efficiency than without "ARE".



(a) With "ARE" (b) Without "ARE"

Fig. 4: The average evaluated value in each agent

Table 1 shows the acquired emergence behaviors as the tactics by the "*eval_mate*[#] function". In case of the # = 1~4, each agent acquired the different behavior, therefore we suspect the emergence of cooperative tactics occured. But in case of # = 5 mutual agent went around the ball, its tactics had the high evaluated value, but we judged that it is not proper as a tactics. In case not using "ARE method", each agent acquired the similar behavior of # = 5 in Table 1 using "ARE method".

Table 1: Acquired tactics by "eval_mate[#] function"

#	Robot1	Robot2
1	Keep a Ball	Wait at the Goal
2	Keep a Ball	Go to near the Goal
3	Go to the Space	Keep a Ball
4	Wait at the Goal	Keep a Ball
5	Go to a Ball	Go to a Ball

5 Conclusion

In this paper, we proposed the "ARE method" which acquires the cooperative tactics by explicitly evaluating the mutual agent of a same kind with using GP, and we discussed the experiment results. As a result, "ARE method" has the following two feature. 「The mutual agent has the synchronization of evolution, so the learning efficiency become higher than the case not using "ARE"」 and, 「"ARE" makes possible the acquisition of specified cooperative tactics and the emergence of plural tactics」.

In the future, we will increase the number of agent, and we will confirm the effectiveness of the "ARE method" in complicated environments.

References

[1] Eiji Uchibe et al. "Co-evolution for Cooperative Behavior Acquisition in a Multiple Mobile Robot Environment" Proc. of IEEE/RSJ International Conference on Intelligent Robots and Systems,1998.

[2] Atsushi Nakamura et al. "Examination of Learning Efficiency in Cooperation Strategy of Robot" Proc.60th National Convention IPSJ,2000.