Construction and strategy of a soccer team by the agent using immune concept

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Abstract

In recent years, the immune system of a living body attracts attention as a new biological information processing based paradigm. In this paper, the concept of the immune system is adapted to the soccer problem which is the standard one of multi-agent system. And new soccer agent is proposed. In the proposed method, appropriate antibodies (agent's actions) corresponding to various antigens (game's environment) are produced and learned. It is verified that agents select optimal and cooperative actions in a dynamic environment using The RoboCup Soccer Simulator.

1 Introduction

Multi-agent system attracts attention as the important research technique of complex system. The reason is it becomes the key to analyzing complex system. Which appears unexpected aspect as the whole system as a result of interaction between agents who become composite element.

Many soccer agents on The RoboCup soccer simulator have been proposed. On construction of effective agent group, performance of the whole system can be clearly evaluated based on an explicit criterion, such as the number of goals. However it is difficult to determine when and how and in what situation agent takes action for team from evaluation point of view and also from selection point of view. It is expected that various knowledge acquired in construction of effective agent group is applicable to general multi-agent system [1]. Murata et al. proposed a method of dynamically arranging soccer agent using genetic Algorithms [2]. Irie et al. presented the way that action value function of various local goal was designed [3]. Kumada et al. showed a soccer agent with ability to predict other agents [4].

The biological information processing mechanism is roughly divided into four parts; a brain nerve system, a genetic system, an internal secretion system, and an immune system. From the engineering point of view, the brain nerve system is modeled as neural networks, the genetic system is also modeled as genetic algorithms and they have been used in many fields. On the other hand, although both the internal secretion system and the immune system have an advanced information processing mechanism, there are few examples applied in engineering.

The immune system came to be especially known well with the latest development of medicine and physiological research. It has an important function how to retain self in dynamic environments except for the simple function eliminating the invaded thing from the external world. An advanced immune processing mechanism is realized. Because each cell takes communication mutually in biological field.

In this paper, we focus on the immune system described above. Immune system of a living body is large-scale system equipped with complicated defense function. This system has function of memory and learning using interaction between cells, such as stimulus and suppression. And this system has the robustness by diversity and the adaptation capability by variation and selection in the immune system. Ishiguro et al. proposed a method of arbitrating between mobile robots using immune network [5].

In the present research, we focus on features of immune system; adaptation capability by variation and selection and robustness by diversity. Concept of immune system is applied to soccer problem. Then soccer agent group using immune concept is proposed. It is verified that appropriate strategies are acquired

through simulation using The RoboCup soccer simulator.

2 Immune type system

Immune type system has features that processing information of immunity. It has the similar adaptation and learning capability to artificial neural network which consists of unit corresponding to immune cell. Unique feature of immune type system is summarized in the following [6].

2.1 Dynamic network

B cells in a living body are seen as a network through antibody. There is hypothesis that B cells build Idiotypic network through antibody. The Idiotypic network has three features; mutual recognition, existence of internal image and relation among immune memory. The network is recognized as a dynamic system of suppression and stimulus between cells. And equilibrium point may move or may add or may delete as a nonlinear dynamic system.

The network of structure of immune system can be flexibly changed as compared with neural network. Namely immune system is a distributed cooperative system with mutual reference.

2.2 Adaptation system by variation and selection

Immune system has mechanism which prepares various antibodies to a strange antigen. However it is impossible to prepare antibody which fit strictly to any antigens in advance. Then in process of immune response, mechanism which adaptively enhances affinity between the antigen and an antibody is prepared by variation of a part of gene corresponding antibodies.

2.3 Robust system by versatility

Coping with unexpected situations, the policy mainly taken by traditional engineering prepares reserves. That is based on redundancy and this realized robustness and fault tolerance. However Antibodies can be almost freely copy. And the reproduced antibodies are slightly different each other. Therefore strategy corresponding to strange element is possible by the above versatility.

3 Proposed system

It is proposed that concept of immune system is applied to soccer problem. First, environmental information which each agent obtains is defined as antigen. Next, soccer team is regarded as one living body. Then action against antigen is determined using a group of antibodies which the team holds. Each agent chooses antibody corresponding to the obtained antigen and determines action.

The proposed system has mechanism which prepares various antibodies to a strange antigen. In soccer problem, it is difficult to set up suitable action to environment in advance. Hence the group of antibodies is changed to select suitable action to environmental information through learning.

3.1 Problem setting

In the present paper, soccer problem is treated. A team is constituted of ten players except for a goalkeeper. Strategy that acquired by the proposed system is analyzed through many games.

3.2 Definition of antibody

Antibody consists of three parts as shown in Figure 1; field position (FP), attribute and action part. Moreover environmental part of antibody is the same structure as antigen which is environmental information.

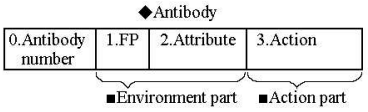

Figure 1: Structure of antibody

3.2.1 Field position (FP)

The size of soccer field is (64 + α) × (105 + α), where is α is a margin. Soccer field is divided into a total of 40 areas of height 5 and width 8. The definition of FP is shown in Figure 2.

3.2.2 Attribute

Attribute expresses environment around each agent. It consists of position of a ball and an own team's agents and opponents and is used for classification of agent's environment. Perceptive area is shown in Figure 3.

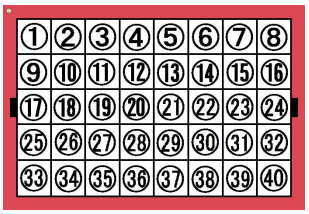

Figure 2: Definition of field position

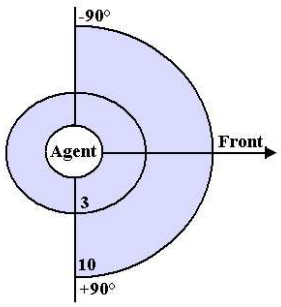

Figure 3: Perceptive area of agent

3.2.3 Action

Action part consists of basic action, an action parameter, and selective value, and basic action is four kinds, kick, path, dribble, and movement. The action parameter is used to decide direction or to choose an own team's agent to pass a ball. Selective value is value which determines probability that antibody will be chosen. The basic action presents a series of actions. For example in case of kick a series of action means agent approaching a ball until it is kicked.

3.2.4 Selection of antibody

In the proposed system, each agent chooses four antibodies which have different basic actions corresponding to antigen from group of antibodies after each agent obtains antigen. Next, antibodies are reproduced in the proportion of there selective values. At this time, small variation is given to action parameter of the original antibody to reproduce difference with antibody. In this way, adaptation capability by variation and selection is given. One antibody is chosen from group of antibodies and action is determined.

3.3 Learning method

As the learning method of the proposed system, the two methods are used when the team gets a goal and agents choose basic actions and practice them.

The learning method when basic action is chosen and practiced is performed if agent's action is successful. Action parameter of selected antibody is approached to that of the reproduced antibody. And this selective value is increased. For example in case of kick judgment of action is decided by whether ball is kicked or not.

In present research, it is noted that a FP is highly important from strategic point of view. So the learning when the team gets a goal is performed by Profit Sharing for every FP.

Furthermore when one antibody is learned, it is rational to perform for antibodies similar to the antibodies. Then learning is performed for FP around FP of selected antibody for the sake of learning convergence.

The equations for learning are described as

$$p_n = p_o + \frac{p_c - p_o}{1.0 + \sqrt{v_o}} \tag{1}$$

$$v_n = v_o + r_b \tag{2}$$

$$v_n = v_o + r_p(t) \qquad (t = 0, \ldots, T-1) \tag{3}$$

where p_o is a action parameter, p_c is an action parameter of reproduced antibody, v_o is a selective value, r_b is a reward for basic actions, $r_p(t)$ is a reward for Profit Sharing, T is the length of history of PS every FP. and v_n, p_n is renewed value.

4 Computer simulation

Each team is constituted using the proposed system. All the soccer games are played on The RoboCup soccer simulator. In one experiment, 50 games of usual The RoboCup soccer are conducted.

For basic action the reward of learning is set to the following values. The reward for kick, dribble, pass and movement is set to 0.1, 0.2, 0.3, and 0.01, respectively. When the team gets a goal, the maximum reward of learning by PS is set to 1.0.

Figure 4 shows the probability to select basic action in case of existence of a ball, two or more friends and opponents in the perceptive area for FP23. As shown in Figure 4, the optimal selection near the goal for kick is realized. Figure 5 illustrates the probability to select basic action in case of existence of a ball, no friend and opponent in the perceptive area for FP24. As shown in Figure 5, the wrong selection near the goal for movement is appeared.

The number of selected antibodies is shown in Table 1. In this table normal means the number of selected

antibodies not including 8 neighbors (8 adjacent FPs) for learning. Then the second row is the number of selected antibodies including 8 neighbors for learning of basic action and third row is furthermore considering PS. After learning the agents in the adjacent FPs tend to select the similar actions to the agent in a FP. In addition there is no remarkable difference in the results whether including 8 neighbors or not.

Selective value of antibodies seldom chosen during games did not be enhanced. Moreover the phenomena that agents are gathering to a ball are seen. This is regarded as one of the reason that capability to search for state is reduced.

The experiment shows optimal actions are partially selected. A cooperative action was not able to be produced as a team. Therefore, improvement is required.

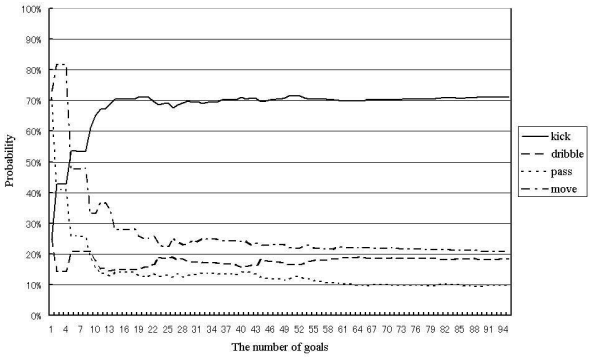

Figure 4: Transition of probability to select basic action when a ball exists and two friends and opponents exists in FP23

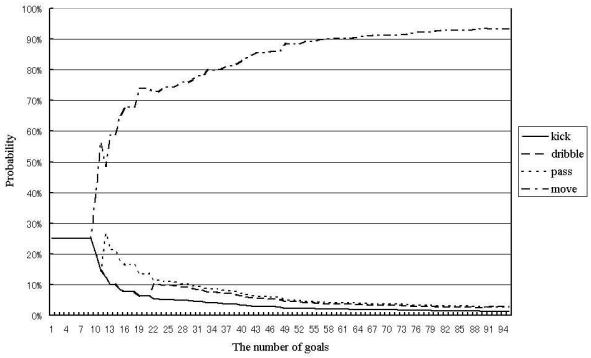

Figure 5: Transition of probability to select basic action when a ball exists and no friend and opponents in FP24

Table 1: The numbers of selected antibodies

Probability to select	more than 80 %	more than 70 %	more than 60 %
normal	3	25	92
including 8 neighbors (only for basic action)	1	20	82
including 8 neighbors (for basic action and PS)	0	0	2

5 Conclusion

In the present research, soccer team by agent using immune concept was proposed. Computer simulation was conducted on The RoboCup soccer simulator, and it is verified that appropriate strategy acquired.

Future problem is to improve learning ability incorporating stimulus and suppression.

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