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Evolution of multiple agent system from basic action to intelligent behavior

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Abstract

In this paper, we introduce the micro robot soccer playing system as a standard test bench for the study on the multiple agent system. Our method is based on following viewpoints. They are (1) any complex behavior such as cooperation among agents must be completed by sequential basic actions of concerned agents. (2) those basic actions can be well defined, but (3) how to organize those actions in current time point so as to result in a new state beneficial to the end aim ought to be achieved by a kind of self-learning self-organization strategy.

Introduction

With the continual development of all kinds of control theories and increasing requirement of higher efficiency in industrial procession as well as in social living, it is not surprising for not only the specialists but also common people in recent to pay so much interests on 'multiple agent system'. Here, the agent is defined as anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effector. Then, a 'multiple agent system' is one that composes of more than two of such agent at least and exits in a extern environment. Apparently such a system can supply better performances, such as higher efficiency, stronger fault-tolerance capacity etc., than conditional one-entity system. Thought all these advantages, it is extremely difficult to built up a ideal applicable system in fact because there are too much uncertainty among the agents' selves and between the system with the extern environment. In my opinion, It seems especially important to build up a general model for such system. It is also the end goal of studies in our laboratory.

Experiment system

In our laboratory the micro robot soccer playing system is used as test bench for the research on the multiple agent system. The micro robot soccer playing game is a kind of robot tournament that is played by two robot teams each of witch must composes three micro robots at least. The rules are driven from the real soccer sport played by men. Up to now several relatively complete regulations have been drawn up by some international organization concerned such as FIFA. The reasons for us choosing such a system as experiment system is for that (1) it is a standard multiple agent system suitable to be studied, (2) it is of flexibility. In other word, we can expand or contract the scale of system easily to meet the needs of our study. In fact, now there are several kinds of methods to organize such a system, with the increase order of difficulty, they are (a) simulation system based on Client/Server network protocol, (b) vision-based centralization system, (c) robot-based decentralization system, (d) humanlike robot system and so on. (3) it is ideal to tell whether one kind of technology better than other or not, for it is a kind of antagonistic game played by two teams.

A kind of wheeled mobile micro robot is used in our experiment system. It is equipped with two nondeformable wheels driven by DC motor independently. We define the 3-vector ζ describing the robot posture with respect to play field, referring to Fig.1.

$$\zeta = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix} \qquad (1)$$

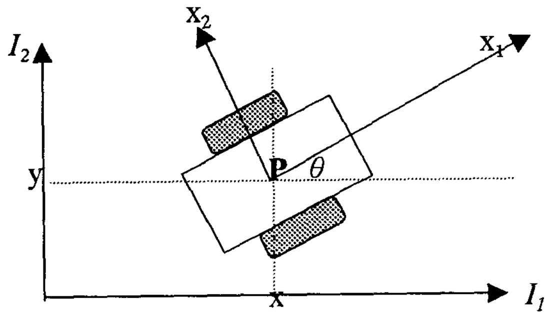


Fig.1. The posture definition.

Here, x,y are the coordinates of the reference point P on robot's frame. θ is the orientation angle of the basis { x_1,x_2 } with respect to the inertial basis {I_1,I_2}.

The overall system adopted in our laboratory is shown as Fig.2.

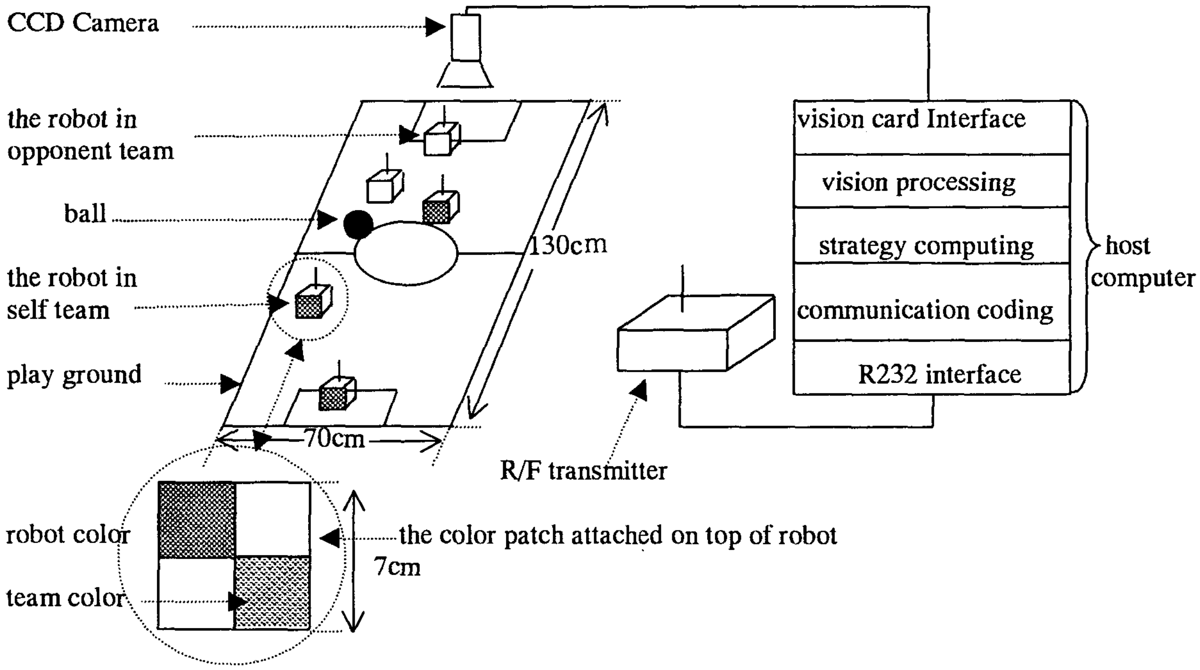


Fig.2. The overall system for micro robot soccer playing game.

Basic actions

In this paper we consider the 'action' as basic movement unit the robot can do, which is different with the 'behavior' that will be achieved by composing a sequence of basic actions defined above.

For playing the game, the following three basic actions are defined in our experiment system. They are

(1) Rotating: To orient the robot without moving from the current position, in other words from current position $\zeta_c(x,y,\theta_c)$ to next position $\zeta_d(x,y,\theta_d)$, $\theta c \neq \theta d$;

(2) GoingTo: To drive robot from current position $\zeta_c(x_c,y_c,\theta_c)$ to destination $\zeta_d(x_d,y_d,*)$, $(x_c,y_c)\neq(x_d,y_d)$. Here * means not consider the heading angle of robot when it reaches the destination P_d.

(3) GoingWithAngle: To drive robot from current position $\zeta_c(x_c,y_c,\theta_c)$to destination $\zeta_d(x_d,y_d,\theta_d)$.This action is not a simple combination of action *Rotating* of *GoingTo* .

Because the robot used in the experiment system is symmetrical in orientation of front and back. The angle to be turned to orient the specified direction will always be less than 90°. We defined such angle as *oration-angle* α ,referring the Fig. 3,

The velocity of left driving wheel and right driving wheel is

$V_{left} = E * \mu * Dis + \text{Sign}(\alpha) * \lambda * \alpha + Adjust1;$ (2)

$V_{left} = E * \mu * Dis - \text{Sign}(\alpha) * \lambda * \alpha + Adjust2;$ (3)

Here,E=-1 if abs(β)>90, else 1; μ is reference value between distance and velocity; Dis=the distance between the current position todestination; Sign()=1 if α>=0,else −1; λ is reference value between *oration-angle* and velocity;*Adjust1* and *Adjust2* is adjust parameter in order to keep the robot from slipping.

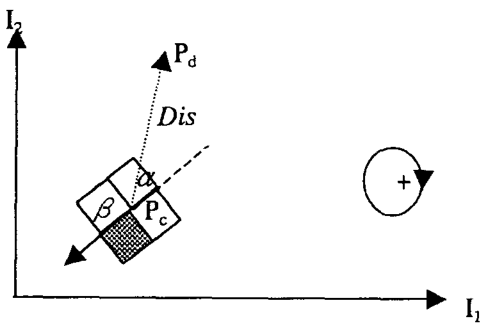


Fig.3. The basic action of robot.

Complex behaviors

Just with those basic actions defined above, the robot can not kick the ball into opponent goal at all. The robot ought to transfer/drib/kick/block/etc. the ball according to the current condition including its own state and relations with other robots. We consider these as 'behaviors'. In other words, the robot must decide where it ought to go in next step so that it is most beneficial for the team to win the game. In our first version of experiment system, we use the *IF/THAN* rules to achieve it. That means we preplan how the robot will do when confronting a special condition. But the result appears not ideal because it is impossible at all for us to estimate all of conditions that may happen in advance. Now we are trying a new method based self-learning self-organization mechanism to evaluate such system. We developed such system using a personal computer installed Intel Pentium 200 CPU based on Windows95 OS. At same time we choice MS Visual C++ as our development language. Whole processing flow is described as following.

(1): Identification and location: By a high performance Vision Capture Card with the technology of Direct Memory Access, our system is capable of capturing vision frame from CCD camera with the sampling frequency of 30frames/second. When we obtain a static vision frame based on YUV color space, at first we identify all objects including robots and ball by the method of color separation. Then we can obtain all information we want to know such as the position, orientation, velocity of objects. In order to describe relation among all objects, we locate all robots respect with to the current position of ball referring the Fig.4.

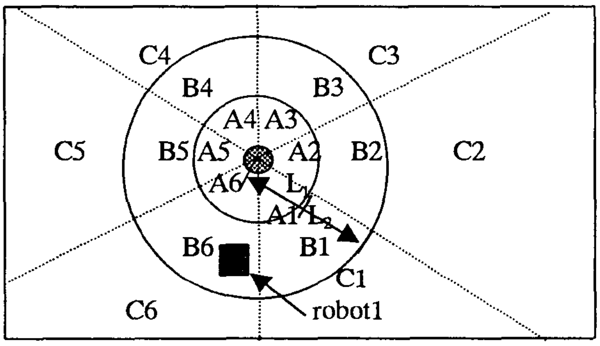


Fig.4. The location of objects.

Then, for example, the roborl is located at the section of C1. In any time the maximum of probability of location of ant object will not over 18.

(2): Training and learning.

To achieve complex behaviors by self-learning and self-organization, we design a data structure denoted *online training strategy library* as following,

The online training strategy library

rec. No.	flag for used/not	current state	next pos.	score
0	1	A1C4B3C4**	B6 B4	* 55
1		----------	----------	----------
⋮	⋮	⋮	⋮	⋮
1000	0	----------	----------	----------

Each record composes 5 items, item1 records the number; item2 shows whether this record is valid, 1 means valid in current and 0 is for invalid record; item3 contains the current state of play field based on the location method shown above. * means the special object can not be identified in current vision frame or we do not concern the special object at all; items4 shows where each robot in home team will go at next step. Referring to the Fig.5.

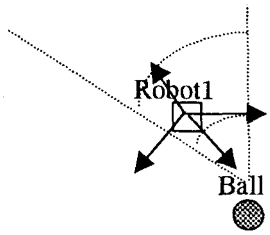


Fig.5. The movement of robot at one step

We decide that at one step a robot only can move to the section adjacent to its current position considering of the fact speed the robot can run. Then the robot1 in Fig.5 only can move to 4 probable sections in next step. Here the * means the special object can not be found in current vision frame or we do not concern it at all; the last item is evaluation score for movements specified at item4 with the current state specified at item3. The range is from –100 to 100.

With the definition above, we drive our robots using the strategy shown in Fig.6. There are three calculation modules called *strategy selecting, score calculating and feedback calculating* separately.

The procession of *strategy selecting* is a comparison and contrast one between the current state in play field with all valid records in the online training strategy library. The each comparison will result in a value denoted as *resemblance value R*

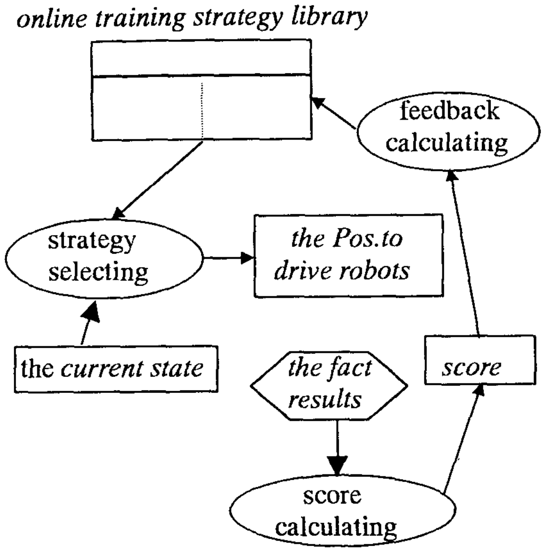


Fig.7. The self-learning self-organization model.

$$R = \sum_{i=0}^{n} p^{i} \qquad (4)$$

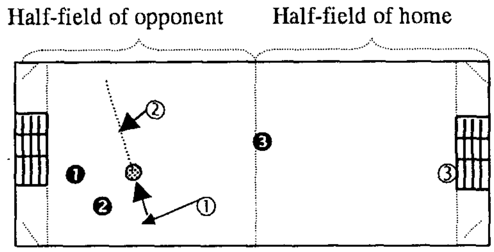
Here $P^i=2$ if the position of i_{th} robot in home team is located at the section specified by the i_{th} field in item3 or according field is *. If not, $p^I=0,;$ For the robot in opponent team, $p^I=1$ if the match successes. The record with largest resemblance value will be selected to decide how the robot will go at next step. If the largest resemblance value is also equal 0, the position of all robots at next step will be decided randomly.

The procession of *score calculating* will score the fact result following the movement resulted by the strategy selecting. In our experiment system, we just use a simple method to score such as: score S+=30 if ball is kicked into opponent goal. S-=30 if ball is kicked into home goal. S+=10 if ball is controlled by robot of home team. S-=10 if ball is controlled by robot of opponent team and so on.

In the end *feedback calculating* is used to adjust the online training strategy library. The score of according record will be changed with the score calculated by the procession of score calculating. For a new condition, it will be added to library. Now the number of record in the library is kept not over 1000. In addition to those simple methods, some new functions for the feedback calculating such as merging, splitting is being added in order to converge more quickly.

Experiment results

For doing experiment, at first we create an initial strategy library manually considering those typical conditions. Then we train such initial strategy library using a simulation system. The three simulated robots driven by the control method shown above play the game with other three robots controlled by man. After we obtain a relatively ideal result. We transfer the online training strategy library to a real experiment system. Now the three real robots driven by the control method shown above play the game with opponents driven by our first version control method. To our surprise, after some time of playing the robots driven by new control method do some cooperation behavior such as that shown in Fig.8.



①②③: players of home team;
❶❷❸: players of opponent team;
⊗ : ball;

Fig 8. The typical attack cooperation

Fig.9. shows the ration of goals obtained by new version system to that by first version system.

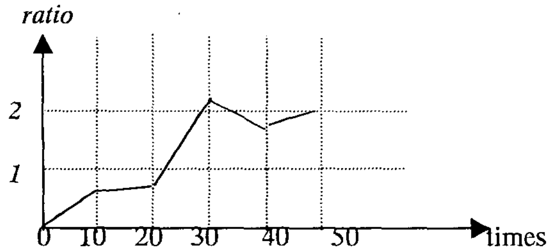


Fig.9. The ration of goals obtained by new version system to that by first version system.

Conclusions

In this paper, at first an ideal experiment system for the study on multiple agent system is introduced. Considering the evolvement of such a system by self-learning and self-organization, a practical method based on personal computer platform is developed. The experiment result shows that new method results in better than conventional IF/THEN strategy. Of cause some drawbacks still exist in new system, such as the procession of score calculating and feedback calculating is too simple yet and the online training strategy library is of unsteady. All these will be resolved in our next version system.

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