Intelligent Hybrid Modular Architecture for Multi Agent System

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Abstract: The purpose of the study of multi-robot system is to realize multi-robot system easy for the control of robot system in case robot is adapted in the complicated environment of task structure. The purpose of the study of multi-robot system is to realize multi-robot system easy for the control of robot system in case robot is adapted in the complicated environment of task structure. To make real time control possible by making effective use of recognized information in this dynamic environment, suitable distribution of tasks should be made in consideration of function and role of each performing robots.
In this paper, IHMA (Intelligent Hybrid Modular Architecture) of Intelligent combined control architecture which utilizes the merits of deliberative and reactive controllers will be suggested and its efficiency will be evaluated through the adaptation of control architecture to representative multi-robot system.

Keywords: Multiple Robot, Control Architecture, Structure of Robot System, Intelligent Control, Soccer Robot

1. INTRODUCTION

Nowadays, the study on adaptation of control architecture based on action based robotics to multi-robot system has been carried out actively. The purpose of the study of multi-robot system is to realize multi-robot system easy for the control of robot system in case robot is adapted in the complicated environment of task structure. The important problems that should be considered in the realization of multi-robot system are as follows:

- Clear realization and modeling of present environment,
- Reconstruction of complicated tasks with efficient simple tasks,
- Efficient allocation of the simple and reconstructed tasks to each robot system, and
- Effective performance of planned tasks.

At this time, the change of environment which are referred to prepared dynamic environment and the dispersion of tasks prevent robot from performing effectively, and these cause the increase of calculation quantity and the time restriction in real time control. To make real time control possible by making effective use of recognized information in this dynamic environment, suitable distribution of tasks should be made in consideration of function and role of each performing robots. The control architectures of robot in the action based robotics are mainly divided into two types of deliberative and reactive type. The control architecture of traditional deliberative type is slow in reaction velocity, but is suitable for the realization of high level intelligence due to the possibility of prediction at the time flow based on circumstance model, whereas the control architecture of reactive type also is suitable for the realization of low level intelligence because it is suitable for the realization of rapid active reaction activity according to sensor input without making use of perfect circumstance model. But reviewing the environment of application field which is really used in robot, there exists prior knowledge known, uncertainty of environment and dynamic environmental change.

Therefore in the application of real system, if either of pure deliberative controller and pure reactive controller is applied, system capability may be decreased. As a result, it is considered that combined utilization using the merit of these two control architectures is effective. Therefore in this study, IHMA (Intelligent Hybrid Modular Architecture) of Intelligent combined control architecture which utilizes the merits of deliberative and reactive controllers will be suggested and its efficiency will be evaluated through the adaptation of control architecture to representative multi-robot system, soccer robot system and experiment.

Firstly, in chapter 2, the state set which relates to environmental model for the robot action and the action set which models robot action will be described. In chapter 3, the relationship between state set and action set will be described. Lastly in chapter 4, the case that the above algorithm is applied to robot system will be described. In chapter 5, the results that is experimented through the application to the soccer robot system of multi-robot system will be shown.

2. STATE SET AND ACTION SET

Reviewing robot action to the planned task, the type of robot action can be mainly summarized as Navigation and Manipulation, and the action of robot is completed with the combination of these or respectively. But in the action of robot, the Manipulation can be largely considered as a problem of Navigation because this can be identified with the problem of Navigation that robot looks for the specific target in case that the end effect of Manipulator moves toward task target. The Navigation in robot has a problem that how fast and correctly it arrives at planned target under the various unexpected environments and dynamic environment which changes at the time. There are very important problems which play a big part in the action of multi-robot because in case of multi-robot, dynamic environment and various unexpected environments exist and occur much more.

In this paper, the concept of state-action was introduced to solve this problem. This was planned to use as a controller of high level which makes the action of robot, and it will be described and applied as a sample of Navigation problem among the actions of robot.

2.1 State Set

If the state set through the surrounding environment modeling is reviewed as a sample of Navigation problem, it shows as follows: If the present and goal angular are set up, the state set of goal and robot can be defined as $S = \{S_S, S_L, S_R, S_{SO}, S_{LO}, S_{RO}\}$. Even though the number of elements in state set differs according to how to model environment closely, in this study, robot, goal and obstacles are mainly modeled as six cases. Figure 1 shows each state.

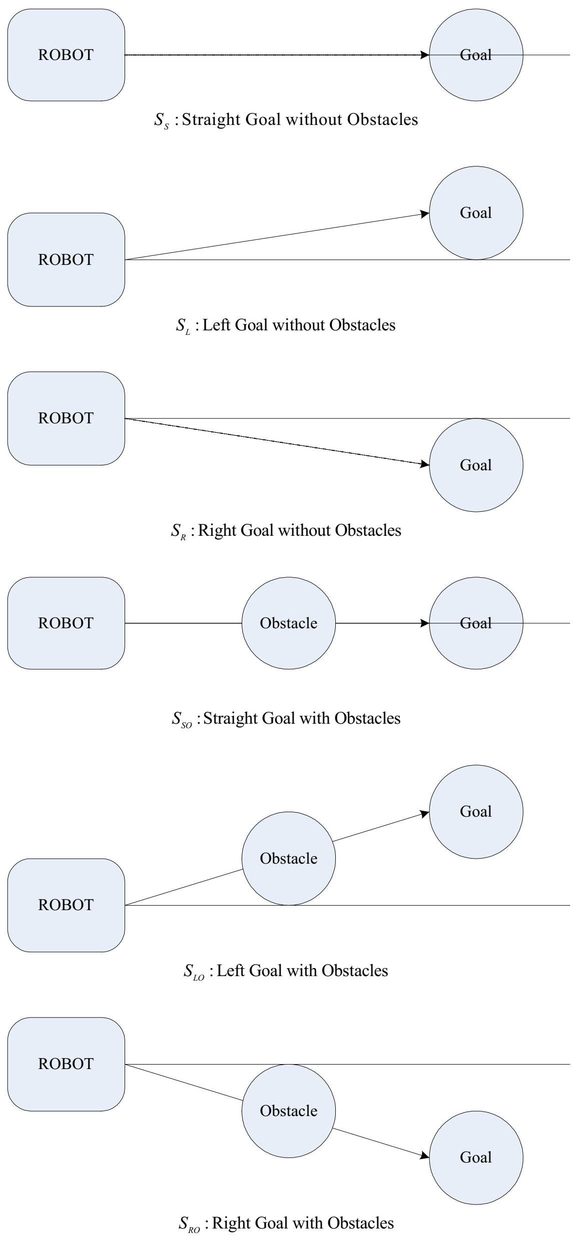


Fig. 1 Environmental Modeling

The process in robot's recognizing the related state through environmental model like this is as follows: in sampling in sequence 'k', the robot compares recognized environmental data with the set of state model, and selects the present state as one of elements within state set. Figure 2 shows blocked descriptions.

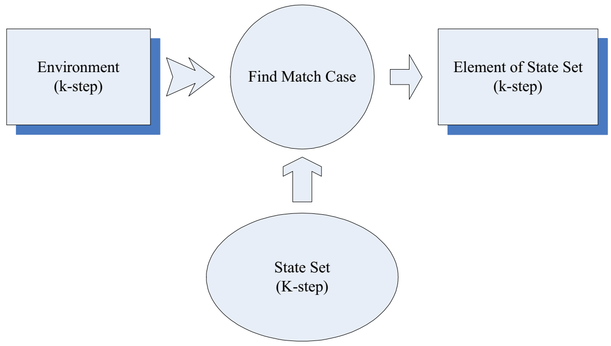


Fig. 2 Search for element in state set

2.2 Action Set

In case of robot's Action Set also, the number of elements will be changed with the accuracy of modeling robot's Action Model, but in this paper we has modeled the most basic actions according to 5 cases, and robot's action is able to be expressed all with these five sort of sets.

Action Set can be defined as $a = \{a_L, a_R, a_F, a_B, a_S\}$, and Figure 3 illustrates it.

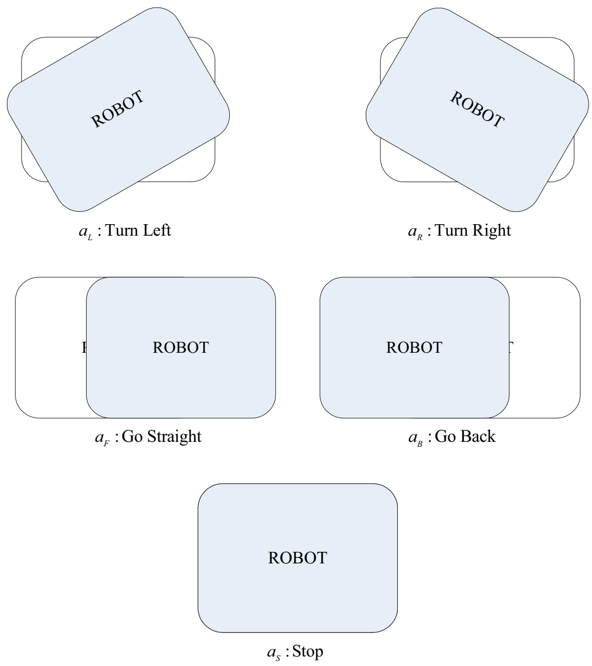


Fig. 3 Action Set

Like this, according to Action Set drawn up with robot's action models and according to state element which is made robot in the action set, we will become to search elements fit for the above in Action Set and to make an action which robot chooses. Figure 4 shows it.

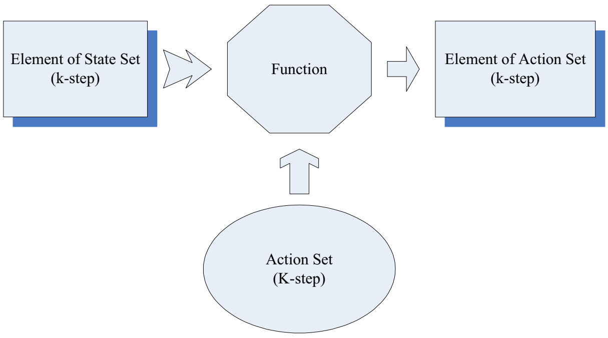


Fig. 4 Search for elements in the action set

3. RELATION TO THE TIME OF STATE AND ACTION

Let the present be equal to k -th sample, we can define that S_k is to be one of elements $S_S, S_L, S_R, S_{SO}, S_{LO}, S_{RO}$ in the set S_k, and a_k action which followed by S_k is to be one ($a_k \in a$) of elements a_L, a_R, a_F, a_B, a_S.

That is, if we assume that the present state of environment model will be S_k, a_k comes into existence owing to S_k and robot become to have an action with birth of a_k and then become to create the follow state S_{k+1}.

The correlation can be illustrated according to the flow of time as the following figure 6.

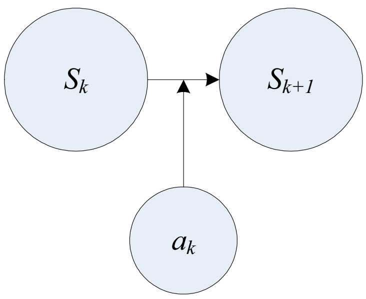


Fig. 5 State $k+1$ is created with the result of action set followed by state set in the system.

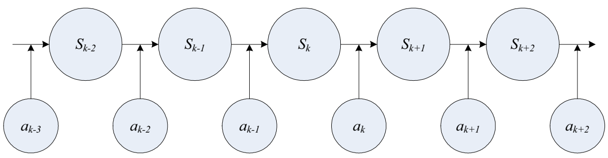


Fig. 6 The following state is created as the result of action set according to state set in the continuous flow of time.

That is, looking around an output of the result, output comes to be presented in the forms that show up the factors of set of α with the time, and if robot carry out actions presented like the above we will be able to get the results converging to the desired state finally.

4. APPLICATION TO THE ROBOT SYSTEM

Drawing up the flow chart of the whole system when robot discharges its duty with a single task, Navigation, we will become to obtain the following figure 7. When the goal is decided, we come to recognize the present state of robot at the part of environment recognition and come to obtain the present state S_k through environmental model set based on the above we become to create a_k through action set.

At the motion generator which belongs to a subordinate controller robot's linear velocity and angular velocity become to be made in the direction of carrying out a_k for the present action state of robot. At the mechanical science, we come to solve the present mechanical science of robot, and come to convert a linear velocity and angular velocity into the velocity of each wheels respectively, and send output data to robot. Then the robot move and create other environment (S_{k+1}).

we come to make the following state S_{k+1} consequently, and this comes to repeat with time continually.

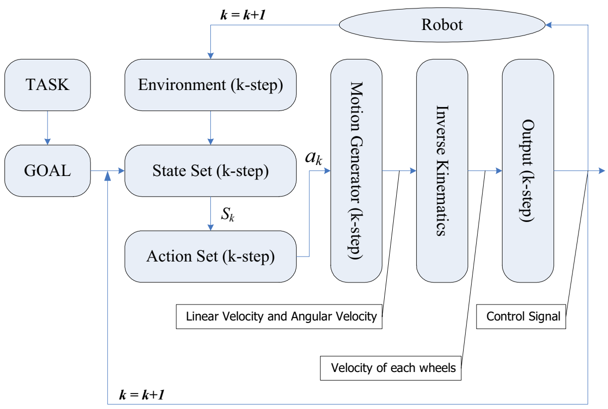


Fig. 7 The flow chart in the whole robot system

Examining the reaction of Action Set according to State Set viewed in the change of robot's location, we can obtain the figure 7 which has the following result.

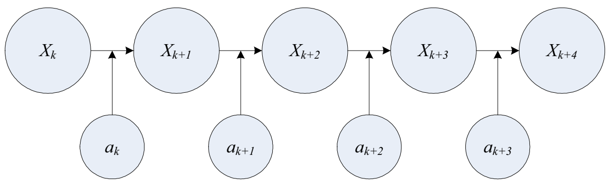


Fig. 8 Change of Action view from change of State Set

Assuming that we say the location according to robot's sample as X_k, and the territory possible to reach from the appropriate location as AX_k , in proportion as we carry out action set a_k ($a_k \in a$) according to State Set S_k. we can obtain the figure 9 which has the following result.

we can look at the following change of X_k and AX_k.

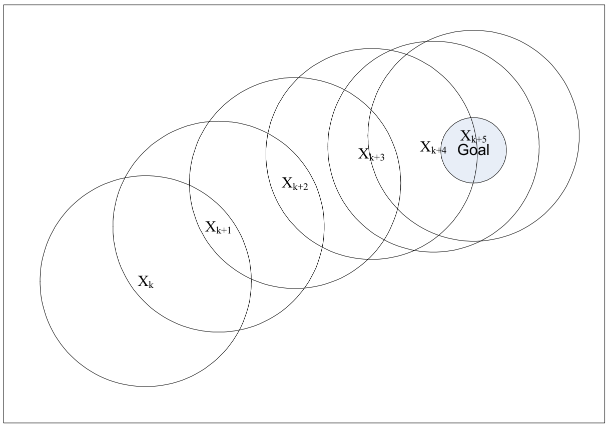


Fig. 9 Change of state view from change of location

AX_k can be defined as follows, when we say obstacle's territory as AX_k A_O , and territory which robot can reach from the present state as AR_k, we can calculate the above such as $AX_k = AR_k \cap \overline{A_O}$ and it becomes to be expressed as the above figure 10.

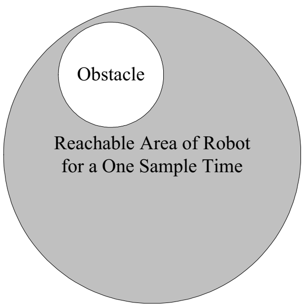


Fig. 10 Territory possible to reach

This location always becomes to satisfy $X_{k+1} \in AX_k$.

Robot can become to converge into desired location with time.

5. CONCLUSION

In this paper, the navigation problem is reviewed through application to robot soccer system, based on an intelligent combined control. In order to verify the above theory, with robot soccer system we carried out navigation with five robots which have each different goal.

In case that five fixed obstacles and five robots move, there exist four moving obstacles exempting own self. That is, the navigation against total of nine obstacles including five fixed obstacles and four non-fixed obstacles was carried out. System structure and necessary time are the same as follows: P4 3.2GHz PC is used for this experiment. And frame rate of the digital CCD camera is 110frames per a second. So system sample rate is 9.9ms. Five robots are posted in the left lower part of soccer field (5:5 235cm X 180cm) and they move toward the right upper part of soccer field. As shown in the figure 11, when it was performed with combined control architecture, it took only 0.05ms for time necessary for state and action algorithm.

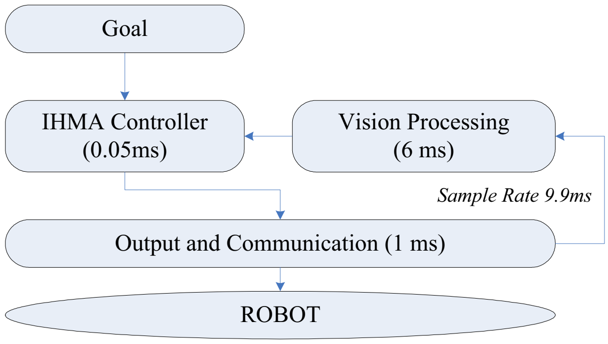
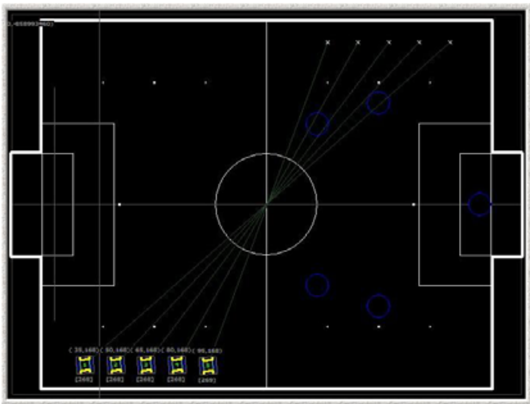


Fig. 11 System flow chart

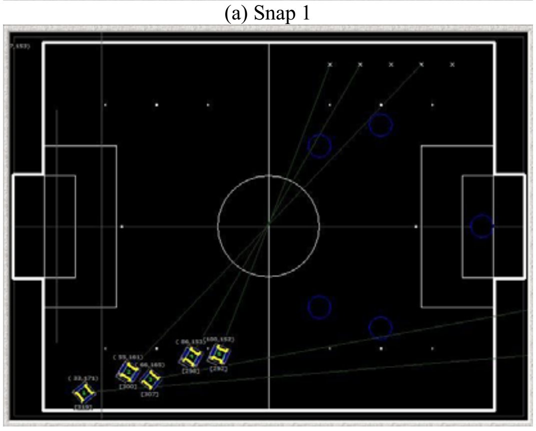
Figure 12 is represented by capturing this performing process with snap shot. The icons of robot is soccer robots, and five circles is fixed obstacles. As shown in the result, it can be found out that these robots smoothly moved toward goal by escaping from robots except for five fixed obstacles (represented by circle) and themselves. It cannot be understood how the movement of moving object (robot excluding magnetism), differently from fixed object is made, but it can be understood that algorithm under circumstances where errors in the process of dealing with vision exist shows its strength and adaptability.

Figure 13 is shown difference path of same task. (a), (b) has a same start and goal position , but paths of five robots is not same. Because of the various unexpected environments and dynamic environment which changes at the time, disturbance, noise, slip of robot, error of vision, error of communication, and etc…

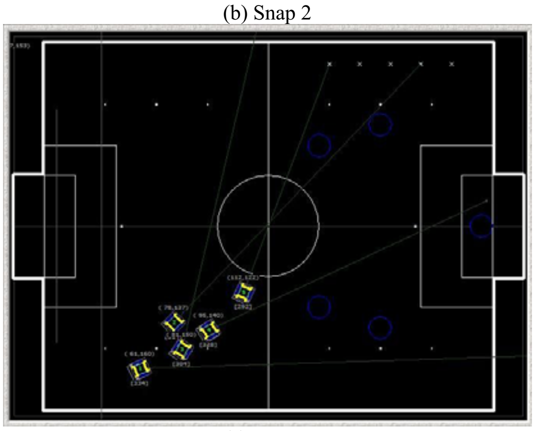
But as shown in the result of experiment, algorithm presented in this study is uncertain and reveals its good capability in the environment which is changed according to time. When robot is used within house, it is uncertain and under changing environment which is changed according to time, same as environment in this experiment. This condition occurs not only in the problem of Navigation but also in the whole action of robot. Therefore if the task given to robot and robot action are modeled based on the concept of environmental model and action model, it is considered that the control architecture showing its strength and adaptability can be designed. Therefore it is suggested that afterwards the capability of controller presented in this study, including the problem of Navigation needs to be evaluated through the application to the task given to robot.



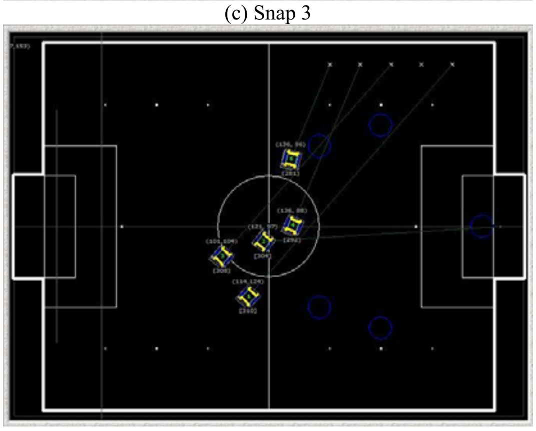
(a) Snap 1



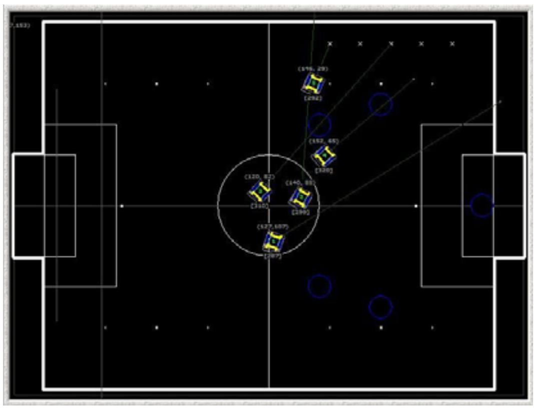
(b) Snap 2



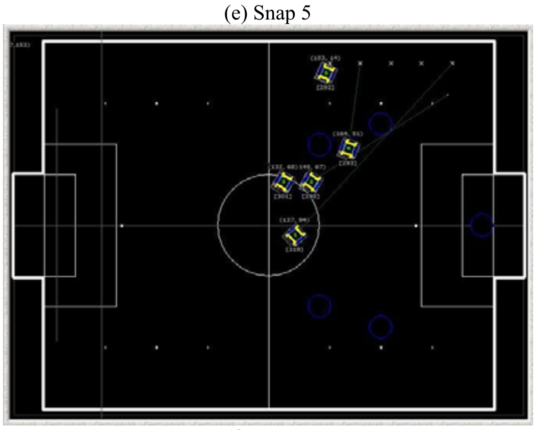
(c) Snap 3



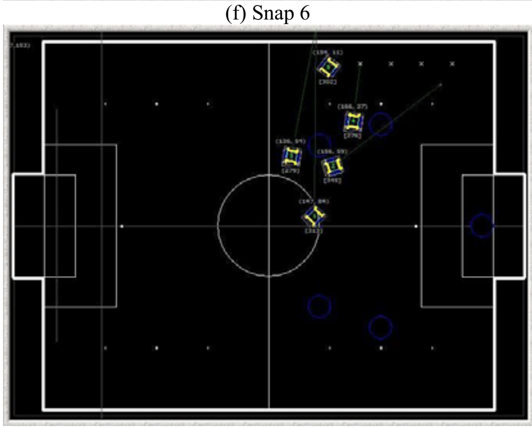
(d) Snap 4



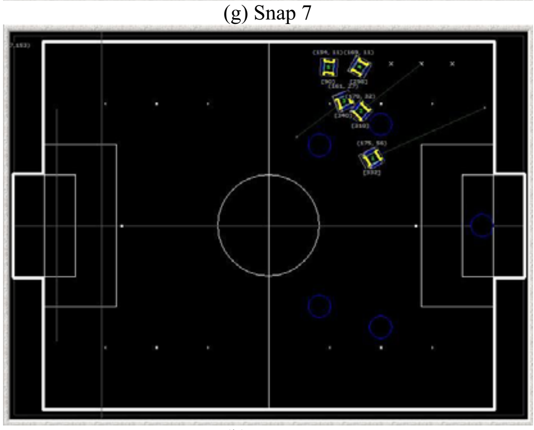
(e) Snap 5



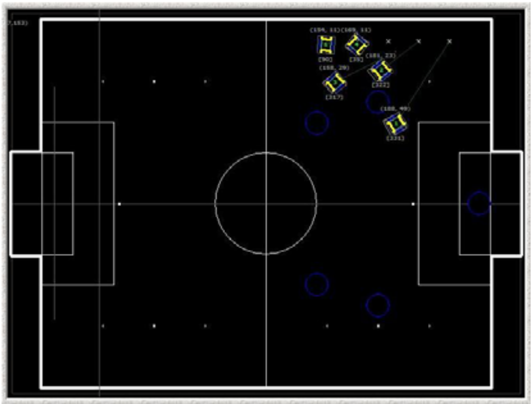
(f) Snap 6



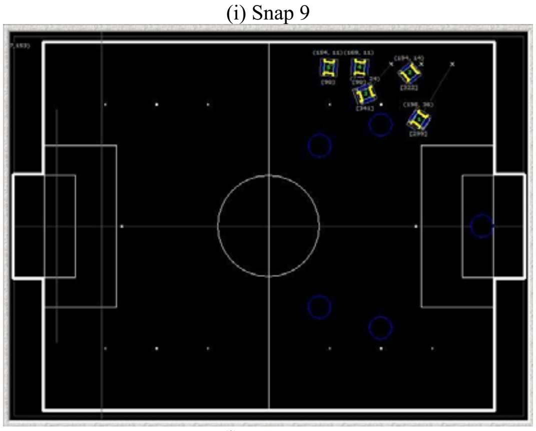
(g) Snap 7



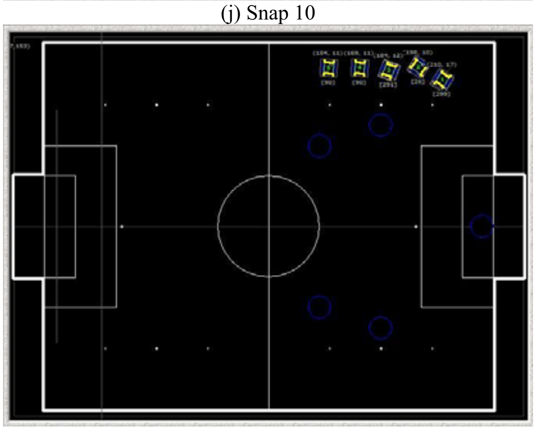
(h) Snap 8



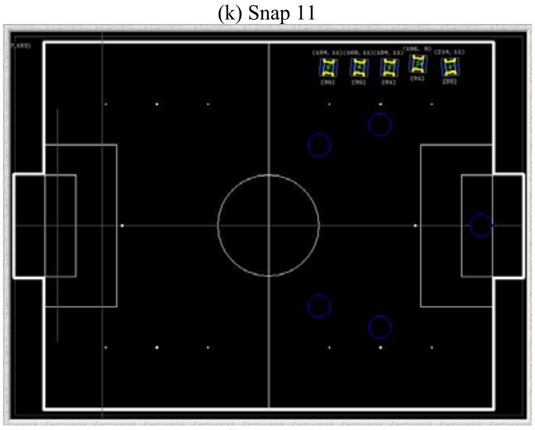
(i) Snap 9



(j) Snap 10

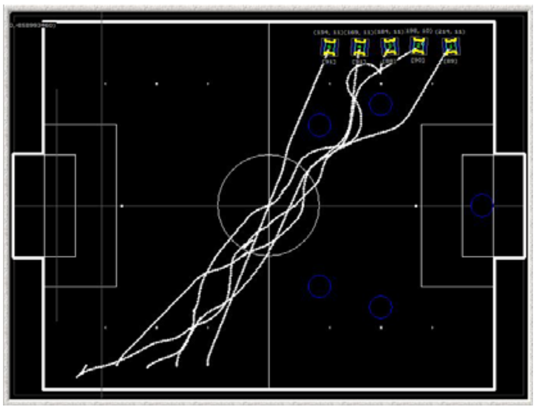


(k) Snap 11

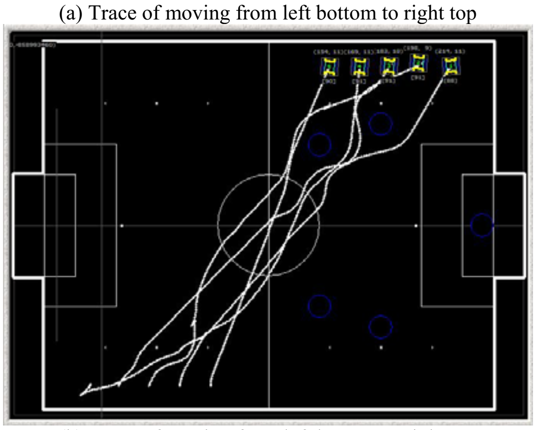


(l) Snap 12

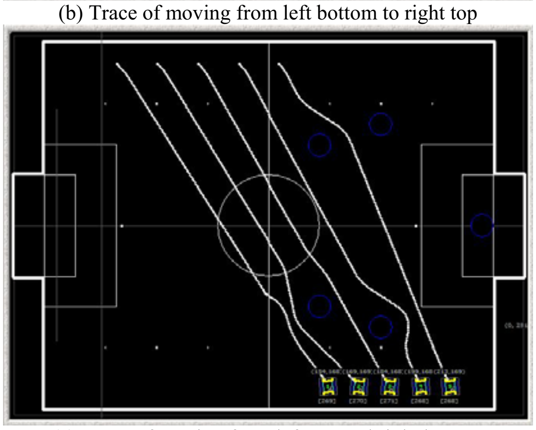
Fig. 12 Snap shot of moving robots.



(a) Trace of moving from left bottom to right top



(b) Trace of moving from left bottom to right top



(c) Trace of moving from left top and right bottom

Fig. 13 Trace of moving robots.

ACKNOWLEDGMENTS

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