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Development a Real-Time Cooperative Approach for Autonomous Soccer Robots Based on World Model Information

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Abstract—**Robocup is an international competition for multi-agent research and related subject like: Artificial intelligence, Image processing, robot path planning, control, obstacle avoidance and machine learning. In this paper we will focus on the Middle size league (MSL). We explain a dynamic role assign algorithm and formation control for robot soccer. The robot soccer game presents an uncertain and dynamic environment for cooperating agents. We believe that a Dynamic role engine is necessary for a successful team. Dynamic role engine and formation control during offensive or defensive play, help us to prevent collision avoidance among own players when attacking the ball and obstacle avoidance of the opponents. The fuzzy logic Role engine and formation control described. In this paper which has already been successfully implemented in Adro Robocup team..**

I. Introduction

Robot soccer games had been popular with educational institutions around the world since the inauguration of the Robocup competition in 1997. This initiative provide a good platform for multi-agent domain research, dealing with issues such as cooperation by distributed control, effective and Fault tolerant communication, real-time image processing, real time robot path planning and obstacle avoidance.

In this paper we present our work in Dynamic Role allocation for a soccer robot team. Dynamic Role allocation allows a team to divide its main objective in a couple of sub-objectives more specialized and adapted to the location of each of the teammates and the strategy of the team. Strategic game play involves role switching for teams with same robots and formation control during offensive or defensive play, collision avoidance among own players when attacking the ball and obstacle avoidance of the opponents.

In Section 2 details our contribution to role allocation problem and strategy decisions for roles in RoboCup. Section 3 analyzes experiments and results we have got. Finally, section 4 summarizes our conclusions using coordination in robot teams.

II. Strategy

In robot soccer systems, images of objects on the field are processed by a vision system. Analysis of this primary data will yield information such as identification of objects including ball, line, player, and opponents. Other information such as object identity (identity of player), opponent, position, orientation and velocity can also be computed. Based on this information, each of the players carries out assigned roles including attacker, defender, supporter and goalkeeper. The simplest role selection strategy is to have a fixed role that does not change throughout the game. However, permanent role causes undesirable behavior such as a defensive player not going for the ball even though the ball is near but outside its defense zone or a forward player giving up its possession of ball when it incidentally enters a defense zone. The main objective in competitive environment is to score goals; and if a player is in a better position to secure a scoring chance, it must be given the opportunity. A cost function evaluates some parameters like the ball distance, localization, player's orientation towards the ball, etc. and obtains a value for each role. This parameters will be calculated periodically and roles will be assigned to robots according to the values obtained.

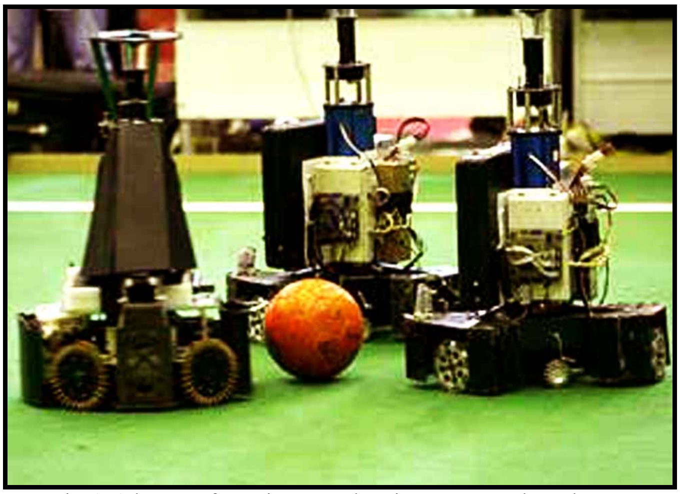

Fig. 1. Adro team formation control against MRL attacker robot

III. Roles Specification

The roles can be assigned to each robot in a statically or in a dynamical way. Dynamic role allocation benefits for example, from opportunistic situations like fast ball changes along the field, or failures in some robot.

We have considered six main roles in the Robocup domain: Goal-keeper, Attacker, Defender (Right Defense, Center Defense, Left Defense), and Supporter. Goal-keeper is the only role assigned statically. The main reason to have a single player to the Goal-keeper role is that the rules do not allow that players enter in its own goal area (like in the hand ball). The rest of roles can be exchanged among robots

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according to game conditions. Next, we are going to describe the objectives of each role and the advantages we have obtained using dynamic role allocation:

a) Goal-keeper: Its goal is to protect its own goal from shots by the other team players. Also, it should rest in its own area.

b) Attacker: It tries to get the ball and to carry it, or to kick it, towards the goal. When the other team has got the ball, it tries to recover it actively (going after the ball). None of the other roles are devoted to get the ball. This approach has one implicit advantage: It avoids collision among players of our team, which is explicitly penalized in the rules.

c) Defender: Its goal is to intercept the ball if an opponent kicks it to its goal. Furthermore, it should stand in the way of the opponent and should try to hide the goal preventing the opponent to kick the ball. Another implicit consequence of the Defender role is that one robot of the team always remains in a position near its own net. This fact is very useful taking into account that the ball quickly moves from side to side. We have always one robot covering its defending half of the field.

d) Supporter: The function of this role is to assist the Attacker in its path, and to cover the maximum amount of field in case the ball will be kicked in the wrong way. The main contributions of this role are to recover the ball if the kicks made by the striker do not go in the good direction, and also to maintain a good position for future passing kicks.

Fig. 2. Defense strategy with two robots

IV. World Model

The World Model is responsible to build a world model using sensorial data. From the sensory inputs and the static information about the game, the Word Model builds the game model, which consists of basic information, like ball position and players postures, and advanced information such as cooperation decisions. The variables used to define the world model are stored in a Blackboard. The Blackboard is a data pool accessible by several components, used to share data and exchange messages among them. Traditional blackboards are implemented by shared memories and daemons that awake in response to events such as the update of some particular data slot, so as to inform the components requiring that data updated. In our implementation, the Blackboard consists, within each individual robot, of a shared memory among the different components, organized in data slots corresponding to relevant information (e.g. ball position, goal position), accessible through data-keys. Some variables of the blackboard are local, meaning that the associated information is only relevant for that robot, but others are global, so their updates must be broadcasted to the other teammates (e.g., the ball position) (Lima 2002). The cooperation is divided in a high-level cooperation and a low-level cooperation. The former one is stored in the Black-board, and consists of Group-Level and Team-Level Tactics, that can be viewed as analogues of the coach's directives in real soccer. The Group Level Tactics defines tactical parameters for the different player groups: defense, mid-field and attack. For instance, a good defensive tactic is to form a defensive line with the goalkeeper to block all paths to our goal. The Team-Level Tactics set general tactical conditions of the whole team. Parameters as basic formation, e.g. 2 defenders - 1 attacker, if we are in a defensive play, or 1 defender - 2 attackers, if we are in an offensive play. The low-level cooperation is outside the blackboard because it is a commitment between the robots that are involved in a cooperative action, e.g. when a robot tells another teammate to move to a certain position, in order to be able to receive a pass. It's necessary to have a communication method between all the robots, so they can exchange messages among them. We pretend to use an Agent Communication Language (ACL) (FIPA 2002), allowing us to use a standard and highly flexible message format.

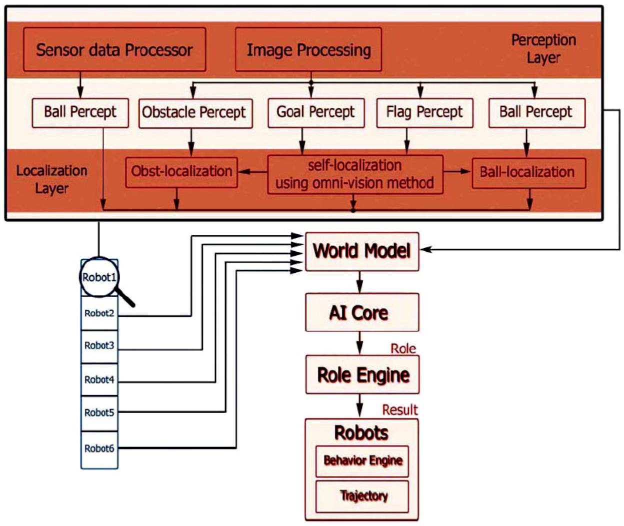

Fig. 3. World model construction and artificial intelligent structure

V. Multi-cost Function for Role Assignment

Role assignment used by many teams is usually computed in real time. Role assignment is necessary to avoid collision of players going for the ball or no player being assign such a role to attack the ball. In this section we are going to introduce some concepts needed to explain how the roles are dynamically assigned. Our role allocation algorithm will be based in Fuzzy Logic. Those functions evaluates some parameters like the ball distance, localization, etc. and obtain a value for each role. A general definition for Parameters that use in fuzzy arbiter is "value to estimate the cost of executing an action". The parameters will be calculated periodically and roles will be assigned to robots automatically according to the values obtained. In our role assignment the Parameters will be individually computed by each robot as inputs to the fuzzy arbiter factors are Distances to ball, goal, path obstacle and etc. These fuzzy variables are defined below and show in figure 1.

1) Distance to ball: is the distance of the robot to the ball.
2) Distance to our goal: is the distance of the robot to our goal.
3) Distance to opponent goal: is the distance of the robot to the opponent goal.
4) Orientation: is the orientation of the robot with respect to the straight line path to the ball.
5) Path obstacle: is the angle bounded between the vector of the robot to the ball and the vector of the robot to the obstacle.

To fuzzily the distance variable, the ratio of the minimum distance To Ball to the distance To Ball value is used, see equation 1. That is, the nearest robot to the ball will have a membership of value 1.0 for this variable.

$$U_{Dis\tan cetoball} = \frac{Dis\tan cetoball\_\min}{Dis\tan cetoball} \quad (1)$$

Describes the membership function for the Orientation variable. A single cosine function is used. The robot that is directly facing the ball will have an orientation angle of 0 degrees, and a membership value of 1.0 for Orientation.

$$\begin{aligned} & U_{Orientation} = Cos(Orientation) \\ & for -90 \le Orientation \le 90 \\ & U_{Orientation} = 0.0 \\ & Otherwise \end{aligned} \quad (2)$$

The 'or' operation used is the algebraic sum operation. All the fuzzy memberships are added together and the resultant is the membership value of the role Assigned. Next are the equations to select the appropriate robot for each role. In this paper we suppose that the order in roles assignment is Striker, Defender and Supporter.

$$\begin{aligned} & U_{Stri\ker} = \min(U_{i,stri\ker}), \forall i \in (1..n) \\ & U_{Defender} = \min(U_{i,defender}), \forall i \in (1..n) \wedge i \ne Robot_{Sri\ker} \\ & U_{Supporter} = \min(U_{i,\sup porter}), \forall i \in (1..n) \\ & \wedge i \ne Robot_{Sri\ker}, Robot_{Defender} \end{aligned} \quad (3)$$

The robot with the highest membership value is assigned the highest priority order among the robots to the role of "attack the ball".

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Every robot updates its utilities periodically, and broadcasts this information to its teammates. We will refer to this information as coordination information.

The information sent is its own location, and an estimation of its distance to the ball. Coordination information is sent at 5Hz. When one robot receives coordination information it updates data associated to the corresponding robot in its global model. This global model stores position of the teammates and, combined with the position of the ball is used to calculate utilities functions.

Fig. 4. Distance to ball certain robot attacker role

VI. CONCLUSIONS

We have developed a basic role engine and formation control mechanism among members of a multi robot team. Localization and local ball estimation are the elements shared. Combining periodically the information received with local information, each robot updates a global model of the environment. Using coordination we have also got a very good way to identify the rest of the team members. In the development of robot soccer where players are homogenous, role engine and formation control becomes a necessity to formulate an efficient strategy to achieve the goal of a successful game. Using a fuzzy rule based approach allows the strategy for role selection to be naturally developed using domain expertise rather than the alternative of trying to find a suitable cost function that would provide the same performance.

Fig. 5. ADRO middle size soccer robot team form Islamic Azad University- Khorasgan branch, Isfahan, Iran

REFERENCES

[1] Gerkey, B., Mataric, M.: On role allocation in robocup. In: RoboCup 2003: Robot Soccer World Cup VII, 2004, Springer-Verlag (2004) 43-53 .

[2] Roth, M., Vail, D., Veloso, M.: A world model for multi-robot teams with ommunication. In: IROS-2003. (2003)

[3] Stone, P., Veloso, M., Riley, P.: The CMUnited-98 champion simulator team. Lecture Notes in Computer Science 1604 (1999) 61-75

[4] Heung-Soo Kim, Hyun-Sik Shim, Myung-Jin Jung, and Jong-Hwan Kim., "Ac-tion Selection Mechanism for Soccer Robot", Proceedings of IEEE international Symposium on Computational Intelligence in Robotics and Automation, 1997, pp390-395.

[5] Hyun-Sik Shim, Yoon-Gyeoung Sung, Seung-Ho Kim and Jong-Hwan Kim, "Design of Action Level in a Hybrid Control Structure for Vision Based Soccer Robo", Proceeding of the 1999 IEEE/RSJ International Conference on Intelligent Robots and Systems, pp1406-1411.

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