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Knowledge-Based Role Allocation

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Abstract

Robot soccer teams consist of a number of robots each performing a different role within the team. The roles discussed in this paper are: goalie, defender, attacker, supporter and centre. These roles are too often statically assigned to the robots at the start of the game. Knowledge-based techniques can be used to assign these roles dynamically to allow the team to adopt the optimal behaviour for each situation. Dynamic strategy choice can also be implemented within the same knowledge-based system. A strategy (defend or attack) can be chosen based on robot and ball location which in turn determines which roles should be used in play. Once the roles are defined, they will be assigned to the best robot for each role in turn based on role importance. Testing within the Teambot simulator shows a significant in score and ball control dominance over the same team with static role allocation. This paper presents the knowledge-based role assignment approach employed and the favourable results obtained.

Keywords: knowledge-based, dynamic role allocation, robot soccer.

1 Introduction

Robot soccer is a competitive, dynamic, multi-agent domain well suited to testing and developing systems [1–4]. Applications of knowledge-based techniques such as image processing [5] and path planning [6] can be applied to robot soccer teams. The aim of this research was to study the advantages of using a knowledge-based approach to perform dynamic role allocation within a robot soccer team. A Knowledge-Based Role Allocation system (KOBRA) was developed and tested using a robot soccer simulator.

2 State of Technology

Robot soccer robots perform different roles to collectively make up the team (roles such as Goalie, Attacker and Defender) [1, 2, 4, 7–9]. Many teams perform this allocation statically [7,10]. Some systems have semi-dynamic role allocation through the use of strategy switching [4] which assigns different roles to robots when the entire team switches strategy. However, this is not entirely dynamic role allocation as it always assigns the same roles to each robot for each strategy. These static role allocation systems are simple and fast but the competitive performance of the teams using them is severely reduced [3, 7].

Dynamic role allocation (roles assigned during game play) can increase the performance of a robot soccer team significantly; as Daniela Coman [7] puts it “Dynamic role switching and formation control are crucial for a successful game”. There are many techniques by which this dynamic role allocation can be performed, the market driven approach [3], using a Petri-net [7, 8], learning algorithms [2] or worthy position computation and assignment [1]. Many mechanisms are available to perform dynamic role allocation system, this problem suits a knowledge-based system because the state of the board can be represented by a set of facts.

3 The Environment

The domain of this research is a robot soccer simulator based on the RoboCup Mid-Sized 2007 rules [11]. Each team consists of five two-wheeled robots operating within the TeamBots simulator environment. TeamBots is a generic robot simulator which can be configured for the RoboCup rules. Each robot can access the egocentric location of the ball, the goals and all other robots. Each robots behavioural code then determines what action to take which is then sent through the path-planning, collision avoidance and motor control modules which work out the actual instructions to be executed.

4 Robot Soccer Roles

The roles and behaviours of the robots in the KOBRA system are designed to mimic the positions played by human soccer players. The roles are similar to the roles used by many teams [1, 2, 4, 7–9]. The following roles and behaviours were decided upon:

- Goalie: Wait at goalie position and keep ball out of goal.
- Defender: Keep ball out of home half or wait at defensive position.
- Centre: Wait at the centre of the field.
- Attacker: Drive ball towards opponent goal.
- Supporter: Drive behind the Attacker.

These roles use the same low level control modules path-planning, collision avoidance and motor control; only the high-level behaviours of the robots are dependent on the role assigned.

5 Role Allocation

Human soccer players will take advantage of any opportunity that arises even if the action is not within their intended range of behaviour. Robots with the ability to switch roles during game play can adapt to the environment by performing the best behaviour possible at any given time thus taking advantage of any opportunities that present themselves.

6 KOBRA

At the start of each iteration, KOBRA will analyse the current state of the game and using its knowledge base, allocates a single role to each robot. If the team is designed to operate over a distributed computer system then this centralised approach does mean there is a potential single point of failure. If the machine processing the KOBRA system has some form of malfunction then the entire team would cease to operate. It would be possible for each machine to run the KOBRA system independently to determine its robot's role. This would more complicated approach would be more robust but slower.

6.1 Implementation

KOBRA itself is implemented in CLIPS and has been interfaced with the Java^{TM} based Teambots simulator [12] using the JClips interface [13]. The actual system is the CLIPS code, the interface to the Java^{TM} is simply used to allow the testing of KOBRA on the TeamBots simulator. The system is implemented in the form of CLIPS rules and facts about the state of the game. Each time the KOBRA system is run it will be initialised with the current state of the system: position of the ball, the position of the robots and the score.

Once the facts about the system have been loaded into the CLIPS knowledge base, the rules of the KOBRA system will be matched to the facts. This matching is done automatically by the CLIPS system which makes it easy to add/remove rules to the system. After the rules have been matched a set of confidence factors for each robot will be produced. Each robot has one confidence factor for each role and this number represents how sure the KOBRA system is that the robot should be allocated that role. For example: if a robot is close to the ball a rule will be matched increasing the confidence factor that it should be the attacker. Likewise if the ball is behind the robot another rule will be matched that will decrease this confidence factor. The KOBRA system is constructed of rules such as these.

6.2 Role Allocation Rules

Once the confidence factors have been calculated the roles are allocated to each robot. The roles are assigned in order of role priority, an approach similar to the method used by [2, 9]. After a robot has been assigned a role, it is removed from the list of robots left to be assigned. The priorities are as follows:

- Assign the Goalie to a fixed robot [3]
- Assign the Attacker to the robot in the best position to drive the ball towards the opponents goal.
- Assign the Supporter to the closest robot to the ball.
- Assign the Defenders as the robots closest to the two defensive positions.

The goalie is statically assigned to the same robot (based upon information from the expert, the goalie should never change and never leave the goal undefended) this is supported by [3]. The next most important roles are the attacker and then the supporter which should always be the robots with the best ability to kick the ball in the direction of the enemy goal. The defenders are then assigned as the

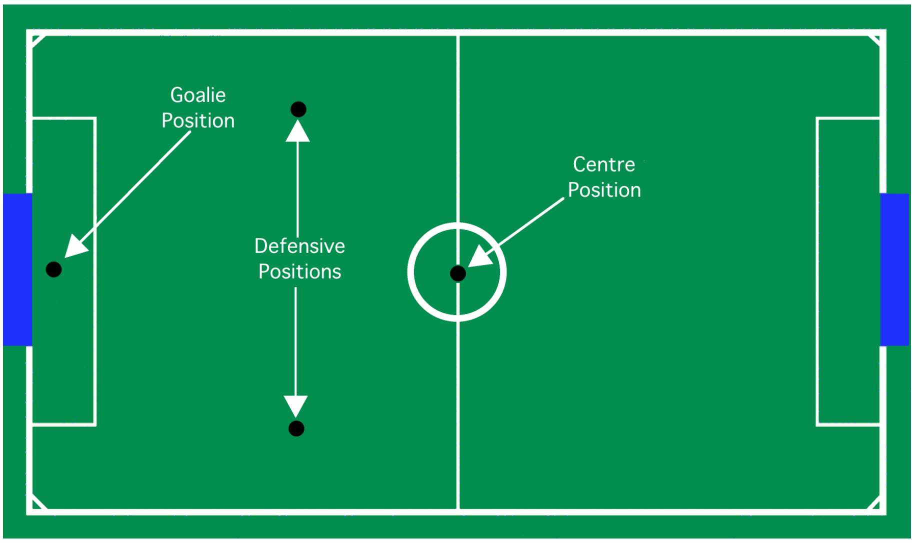

Figure 1: An illustration of the positions used by the KOBRA system roles on the robot soccer playing field.

robots closest to the defensive positions. See Figure 1 for role positions.

6.3 Role Allocation Strategies

One feature of KOBRA is that by changing the roles assigned to the robots and the priority of those roles, KOBRA can be used to implement different strategies. A strategy consists of different roles and playing positions [4, 9, 14]. These strategies can be used to make the team perform differently in its entirety based on the state of the game and improve the performance of the team [14]. The two strategies that have been currently developed for KOBRA are similar to the strategies developed by other teams [4]. The defensive strategy is designed to protect the goal at all costs and try to force the ball back over to the other side of the field.

The offensive strategy is designed to take more risks and to attack the enemy goal more aggressively. The offensive strategy also keeps some robots back to defend the goal should the attack on the opponent goal be unsuccessful.

KOBRA decides which strategy to use by analysing the positions of the robots in relation to the ball and the goals and determines threat values for each robot. If the home team is under more threat than the opponents, (for example if the entire opponent team is in the KOBRA half and have control of the ball) it will use the defensive strategy. If the opponent team is under more threat it will use the offensive strategy. This decision is made based on confidence factors calculated in the same way robots are assigned roles,

Table 1: Performance comparison of role allocation techniques.

Teams	KOBRA	Massey	Ball Control
KOBRA S vs MUT	1	0	88.24%
KOBRA A vs MUT	2	0	75.19%
KOBRA D vs MUT	0	0	87.37%
KOBRA S vs MUTU	1	0	88.89%
KOBRA A vs MUTU	0	0	80.14%
KOBRA D vs MUTU	1	0	89.25%

by the CLIPS environment matching rules based on facts about the state of play.

7 Testing

The testing for KOBRA was performed by playing KOBRA against the original Massey University Team (MUT) and the Massey University Team Updated (MUTU) using the attacking strategy (KOBRA A), the defensive strategy (KOBRA D) as well with strategy switching (KOBRA S).

In Table 1 the KOBRA and Massey columns show the scores for the two teams; in each scenario KOBRA either wins or ties with the Massey team. The ball control column shows how much time the ball spends in the Massey teams half. The ball control shows how the KOBRA team is extremely dominant in terms of ball control. The attacking and defensive strategies perform differently depending on the team they are playing, whereas with strategy switching, KOBRA performs more consistently despite which team it is competing against.

8 Observations

During game play, the following observations were made of the behaviour of the teams. The MUT and MUTU robots in defensive roles would drive the ball over the half way mark and attack until the ball was pushed away out of their control area, they would then turn around and return to their defensive position. Only the specified attackers would actually continue to chase the ball and try and score a goal. However, when the KOBRA defending robots were in the same situation, they would be allocated the role of attacker and would drive the ball towards the goal and continue to chase it if the ball was stolen. The other robots would be assigned the roles of defensive so as to always fulfil the requirements of the chosen strategy.

9 Conclusion

Testing has provided encouraging results; the KOBRA team can outperform the original MUT and MUTU robots in terms of ball control and score. The KOBRA system was observed to solve the problem of robots not taking full advantage of opportunities arising in the game. The KOBRA system is an improvement on the previous team and this research shows that knowledge-based systems are both viable and applicable to robot team coordination.

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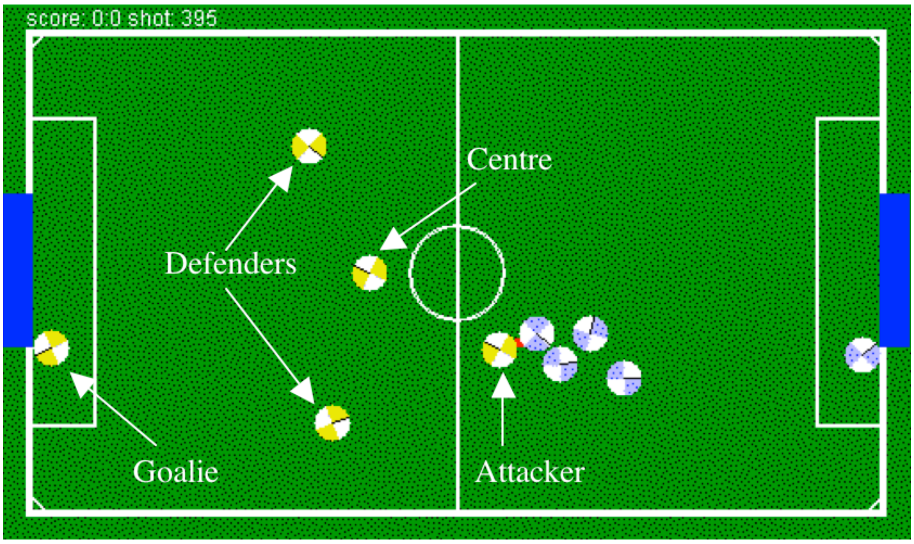

Figure 2: Screen shot of KOBRA vs MUT. Shows the roles KOBRA utilises with the defensive strategy: Goalie, Defenders, Centre and Attacker. Note that when the defensive strategy is active the attacker will still drive for the ball while the other robots maintain their positions until the ball moves closer towards them. It is also worth nothing that the Massey team robots are all crowding around the ball and getting in each others way which reduces their effectiveness.

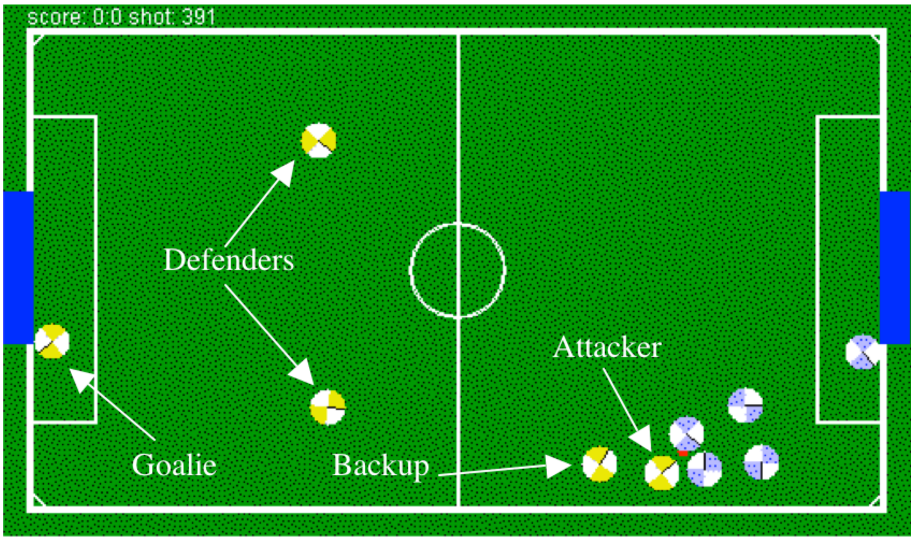

Figure 3: Screen shot of KOBRA vs MUT. Shows the roles KOBRA utilises with the offensive strategy: Goalie, Defenders,Backup and Attacker. The attacker is driving the ball towards the goal and the backup robot is driving behind the attacker to catch the ball if it is kicked past the attacker. Note also the Massey robots which are again all crowding around the ball in an attempt to stop a goal, this is not an efficient strategy.