Discovering Tactical Behavior Patterns Supported by Topological Structures in Soccer-Agent Domains

(Short Paper)

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ABSTRACT

Behaviors in soccer-agent domains can involve individual plays, several players involved in tactical plays or the whole team trying to follow strategies supported by specific formations. The discovery of such behaviors needs the tracking of both the positions of players at any instant of the game and relevant relations able to represent particular interactions between players. Nevertheless, the tracking task becomes very complicated because the dynamic conditions of the game implying drastic changes of positions and interactions between players. We propose in this work a model able to manage the constant changes occurring in the game, which consists in building topological structures based on triangular planar graphs. Thus, based on this model tactical behavior patterns have been discovered even the dynamic conditions. Experimental results show that the proposed model is able to manage the constant changes of the world and discover tactical behaviors patterns. For that, an important number of matches have been analyzed from the RoboCup Simulation league.

Keywords

Pattern recognition, topological structures, tactics.

1. INTRODUCTION

Individual behaviors, behaviors that involve two or more players and team behaviors, such as formations, can be distinguished in a soccer match [9]. Some of the most important behaviors are related with tactical plays. In general, tactical plays are most of the time planned and they should occur under the context of formations. A formation is a structure based on positions of soccer-agents and relevant relations between them. For example, a code 5:2:3 represents a formation composed by five defenders, two midfielders, and three forwards. Goalkeepers are not counted because they are the one position forever. In general, strategies should be supported by formations in order to assure order, discipline and organization during a match [6]. The value to recognize a formation of a team is because it reveals part of the strategy of the team [11, 10]. The discovery of tactical or team behaviors needs the tracking of both the positions of players at any instant of the game and relevant relations able to represent particular interactions between players. Nevertheless, the tracking task becomes very complicated because the dynamic conditions of the game bring about drastic changes of positions and interactions between players, which difficult the construction of models capable of discovering behaviors of teams playing soccer matches [7]. We propose in this work a model able to manage the constant changes occurring in the game, which consists in building topological structures based on triangular planar graphs. Thus, based on this model tactical behavior patterns have been discovered even the dynamic conditions. Offensive tactical plays have been discovered. The discovered tactical plays describe a path starting, most of the time, from a zone around the middle of the terrain and then distributed either to the right or to the left side until players reach a zone close to the goal where a player possessing the ball search for shutting the ball to mark a goal. Some of these plays ended as a goal, and others failed but they were very close to reach the desired objective, that is, to mark a goal. Experimental results show that the proposed model is able to manage the constant changes of the world and discover tactical behaviors patterns. For that, an important number of matches have been analyzed from the Soccer Server System, used in the Robot World Cup Initiative [5].

It is emphasized that general behavior patterns describe not only the path of the ball, but also the players participating in the play and the zones where the tactical play have taken place.

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2. RELATED WORK

Our approach is related to the work of Visser and colleagues [11] that recognizes the formation of the opponent team using a neural networks model. This work feeds the observed player positions into a neural network and tries to classify them into a predefined set of formations. If a classification can be done, the appropriate counter formation is looked up and communicated to the players. The main difference to our approach is that Visser and colleagues do not

represents the multiple relations between players.
The ISAAC system [8] is an automated game analysis tool for simulated robotic soccer. It employs a local adjustment approach to suggest small changes (such as ”shoot” when closer to the goal) to a team’s designer in order to improve the performance. The suggestions are backed up by examples from the games previously analyzed and provided in a useful format easy to examine by the designers. However, to analyze the behavior of a team, ISAAC identifies successful or failure patterns of actions of multiple agents without consider the formation of a team.
Modeling the behavior of a team is presented by Kaminka [4]. The main idea is to take time-series of continuous observations and then parse and transform them into a single-variable time-series. The authors use a set of behavior recognizers that focus only on recognizing simple and basic behaviors or the agents (e.g., pass, dribble). Their approach is based mainly on the tactic of the team without considering the formational behavior of the team.
The work [2] from Bezek and Bratko presents a method to discover pass patterns incorporating domain knowledge and provides a graphic representation for detected strategies. The focus of such work is toward increase human comprehension without prior strategic knowledge. Although their approach obtains tactical behavior patterns, they only consider the players involved in the passes without taking into account the team behavior.

3. DISCOVERING TACTICAL BEHAVIOR PATTERNS

This section is composed of two parts: the topological model principles and the algorithm to discover tactical behavioral patterns.

3.1 Topological model

Definition of topological graphs. A graph G is planar if it can be represented on a plane in such a way that the nodes represent different points and two edges should be encountered only at their ends. The intersection of two edges out of their ends breaks the planar property of the graph G. This graph G is also named as planar topological graph [1]. Two or more graphs are topologically the same if they can be transformed by elastic deformations until their form coincides, as shown in Figure 1.

The tactical plays are submitted to formations, in such a way that if a formation change or seems having changed, tactical plays are affected. Then, topological structures should guarantee that changes in formations have taken place if and only if the planar properties of the graph, representing structures, have been broken. Otherwise, formations have not changed.

This work uses a topological structure model based on relevant relations. The relevant relations used to build the topological structure are related with the notion of neighborhood. Thus, an agent remains related with his closer neighbor belonging to his zone (defensive (D), medium (M) or attack (A)), and his closer neighbor belonging to the neighbor zone as illustrated in Figure 2(a) and Figure 2(b). Figure 2(c) shows the integration of both kinds of relations for a 5:2:3 formation.

3.2 Tactical Behavior Patterns

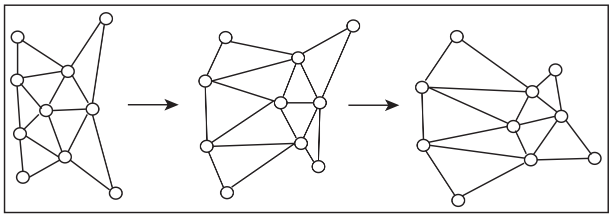


Figure 1: Three representations of the same topological graph

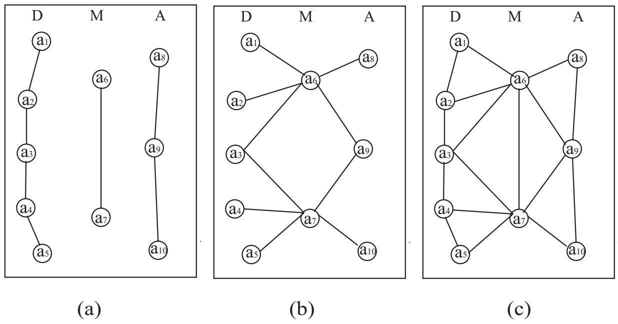
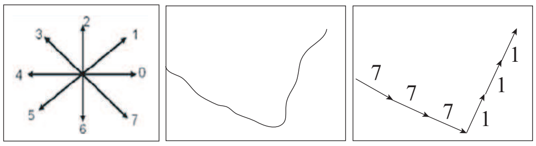


Figure 2: (a) Neighbor nodes of the same zone are linked. (b) Neighbor nodes for neighbor zones are linked. (c) Topological graph including both kind of links.

The process to discover tactical behavior patterns is described by the following six steps:

- *Step 1.* **Read logfile**. Input data mainly related with players and ball positions;
- *Step 2.* **Extraction of similar paths**. A set of ball’s paths occurring under similar contexts are extracted. For instance, Fig.3 shows paths starting from the middle zone of the field and then distributed either to the right or to the left side until ball reach a zone close to the goal;
- *Step 3.* **First Freeman codification**. The set of paths are coded to be represented by a sequence of digits using the code of Freeman [3]. For instance, Fig. 4(c) shows the freeman representation which corresponds to the path shown in Fig. 4(b). In this case, the freeman code is *7-7-7-1-1-1*;

Figure 3: Paths indicating approaches of the left team to the opposite goal



(a) (b) (c)

Figure 4: A Freeman codification of a path

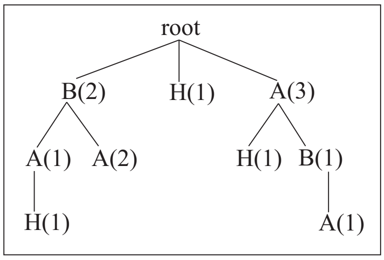


Figure 5: A trie resulting from the two paths: BAH and ABA. Numbers in parenthesis are the nodes counts.

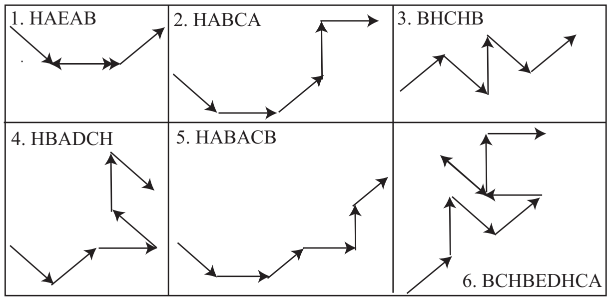
- *Step 4.* **Second Freeman codification**. The sequence of step 3 is recoded to obtain a more abstract code. Let **A,B,...,H** be the new abstract segments where each one represents a freeman code sequence with the same orientation, such that, **A** represents the sequence of *0*'s, **B** represents the sequence of *1*'s, and so on. Thus, a path coded as *7-7-7-1-1-1* can be represented by the code **HB**;
- *Step 5.* **Discovering of generalized patterns**. Identification of most frequent sub-sequences. A method based on a generalization of a tree is applied to discover the general behavior patterns representing the paths of tactical plays. For instance, let's take two paths: **BAH** and **ABA**. Let's suppose that the trie is empty. It will first insert **BAH** into it. It will then insert the two remaining suffixes of **BAH**: {**AH**, **H**}. Next, it will then insert the next path and its suffixes: {**ABA**, **BA**, **A**}, into the trie. The most common single sub-sequence is **A**, the most common two sub-sequences is **BA** (see Fig.5);
- *Step 6.* **Association of players and zones**. The topological structures used to track formations have been a very good support to determine the players participating in tactical plays, as well as the zones through which the plays have taken place.

4. ANALYSIS OF RESULTS

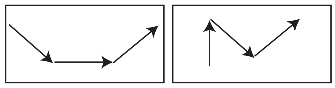
About 10 real matches of different years of the Robo-Cup Championship were analyzed. A set of paths of one of theses matches is shown in Figure 3. The paths correspond to attack strategies. This match was played by TsinghuAeolus soccer team. From the point of behavior, what is important is not the long of the path but the form of the path and the intention of it. In order to facilitate this interpretation, the paths have been coded two times using the Freeman Codification. Thus, through this double codification, the transformation of original paths into more abstract paths is shown

1.	7777770000000044444000000000000000011111111011111
2.	7777777000000000000111111222222222222000000
3.	11111217777777722222267777777711111111111111
4.	777777000007777777777111111111111000000003
5.	777777777777770000000000011111111110000002222222
6.	1111112222220777777777711111114444333777777722222200000

(a)



(b)



(c)

Figure 6: Transformation of original paths into more abstract paths. Attacking paths through the right side

in Figure 6 and 7. This representation provides us with information about the form of the path, the start and the end zone of the path. Another advantage is that the algorithm to generalize paths described in section 3.2 can be applied more efficiently using this more abstract representation.

The topological structures serve not only to manage the dynamic nature of the game through an efficient tracking, in addition these structures provide us with important information about the players participating in the match and the zones through which the plays have taken place.

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5. CONCLUSIONS

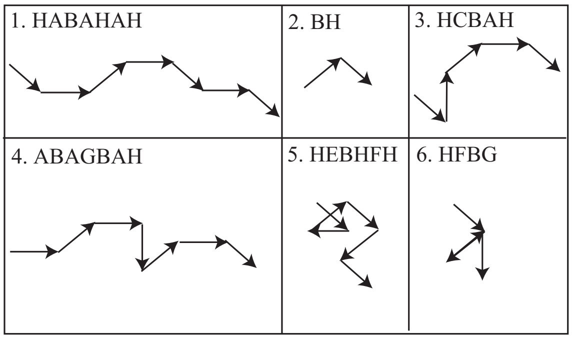
The discovery of tactical plays and formations supporting strategies of team represents relevant information to implement counter strategies or tactics to reduce the performance of the opposite team or, in the best of cases, to beat it.

Nevertheless, the dynamic nature of soccer matches along with the multiple interactions between players difficult enormously the task of discovery. The model based on topological graphs has contributed importantly to manage the difficulties due to the dynamic nature of the soccer game. It can facilitate the tracking of formations and provide the algorithm of discovery tactical plays with important information concerning the players participating in such plays.

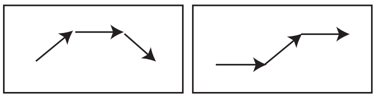
Another contribution described in this paper is related with the double codification of the paths, which has facilitated the interpretation of paths to implement the algorithm described in section 3.2.

1.	7777777700000000011111100000000000077777777000000000777777
2.	111111111111111111111177777777777777777777777
3.	77777777777722222222211100000000777777777777
4.	00000000001111111111000000666666111111100000000777777777
5.	77777777774444444444111111111777777777555555557777777
6.	7777755555555551111111111111111166666666

(a)



(b)



(c)

Figure 7: Transformation of original paths into more abstract paths. Attacking paths through the left side

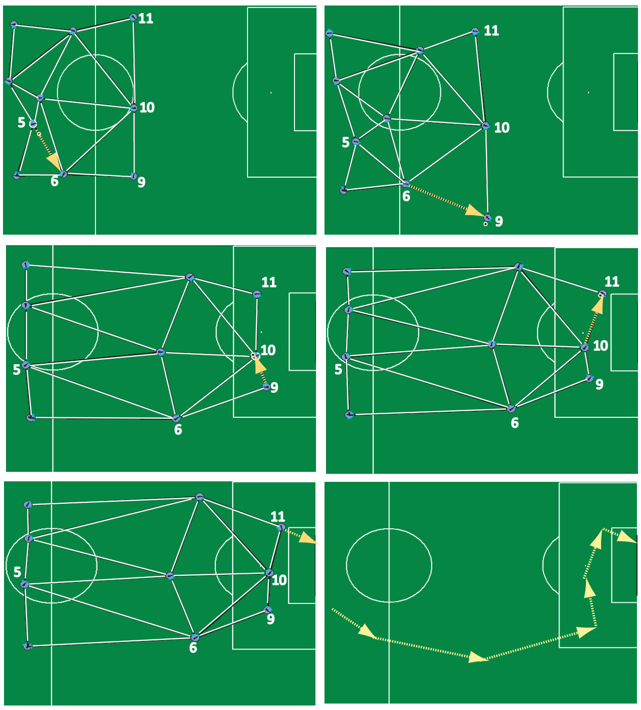


Figure 8: Sequence of frames representing a tactical play supported by a 4:3:3 formation. Passes occurred between players: 5-6-9-10-11. The last frame shows the ball's path for this tactical play.

The discovered paths can be considered as generalized because they were obtained from a set of paths by applying the generalization algorithm described in section 3.2.

As future work the discovery of defensive tactics is necessary to have a richer spectrum of the tactics used in a match.

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