i-footman: A Knowledge-Based Framework for Football Managers

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Abstract. i-footman constitutes a knowledge-based framework aiming to provide assistive services to football managers. More precisely, the system accommodates a number of managing processes (e.g., selection of team composition) in the context of football by adopting a declarative approach. It also takes advantage of Semantic Web technologies in order to represent and manage the required application models. i-footman is based on a flexible architecture that facilitates possible extensions in the functionality and the quality of the provided services. The paper presents the overall architecture as well as certain implementation details of the system.

Keywords: knowledge-based system, reasoning methods, ontology, rules

1 Introduction

This work presents an extensible knowledge-based framework aiming to provide team management services in the context of football. The system allows the development of services that can be used by football managers. Specifically, i-footman (*i*ntelligent *foot*ball *man*ager) supports some pre- and in-game decisions needed to be taken by the user. The basic functionality of i-footman consists of proposing a "good" tactical formation, an effective composition of players and certain tactical instructions.

Football does not constitute a scientific field or a domain with explicitly expressed and commonly accepted knowledge. This is due to the fact that knowledge about football does not stem only from expertise but also from experience. Moreover, there are times when domain experts (i.e. football managers) act differently to each other in order to face a certain situation (e.g., suspension of a player) making the knowledge about football subjective. Hence, i-footman does not aim to capture the complete knowledge about the application domain of football, but to provide effective means of adapting and extending the required knowledge according to the user needs.

The suggestions of the system are based on domain-specific knowledge such as the opponent's team tactic and the features of the available players. Such kind of knowledge had to be modeled through appropriate application models. However, no such model was identified in the relevant literature. Additionally, i-footman is a decision support system and it calls for effective modeling of human knowledge and expertise. Hence, the system had to exploit proper knowledge technologies and representation formalisms that would facilitate the extensibility of the knowledge base. Consequently, modern techniques (e.g. Semantic Web technologies) were adopted in the context of i-footman in order to represent knowledge through expressive languages. The adoption of rules and ontologies take advantage of the declarative programming paradigm by exploiting natural forms of knowledge.

The rest of this paper is organized as follows. Section 2 discusses the architecture of i-footman and some modeling issues, as well. A functionality and performance evaluation that has been performed in a simulated environment is presented in Section 3. Finally, some concluding remarks are provided in the last section of the paper.

2 System Architecture and Application Models

Two ontological models have been developed in the context of i-footman for modeling football players and teams, accordingly. Furthermore, a large set of rules was composed in order to express more complex concepts and relations. Two domain experts were interviewed in order to acquire the domain knowledge captured by models and rules[1]. The Pellet reasoner (v. 1.5.1) [6] that is based on Description Logics (DLs) [1] is responsible for reasoning over the ontologies while the rule engine Jess [4] performs the execution of rules. The selection of the reasoning modules is based on the performance evaluation presented in [5]. The integration of ontologies and rules is not a straightforward task, since there is no single reasoning module that can seamlessly handle both formalisms. Hence, i-footman performs reasoning tasks in a sequential manner and the results of the ontological reasoning are provided as input to the rules execution process. A generic view of the framework architecture is depicted in Fig. 1.

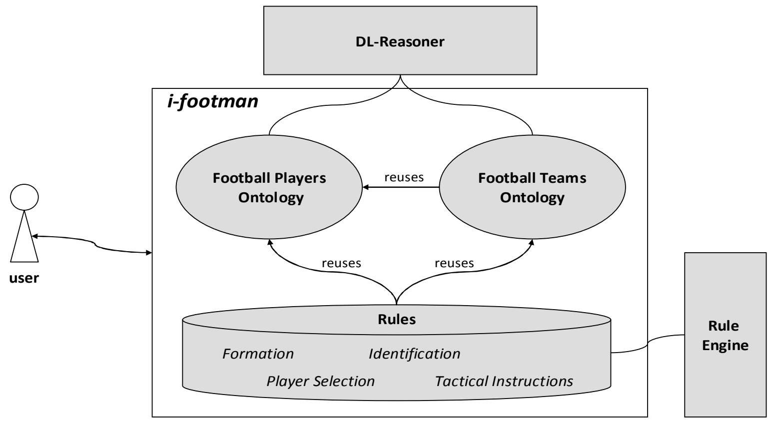

Fig. 1. i-footman Architecture

[1] All the application models and rules developed in the context of i-footman are provided online in *http://www.di.uoa.gr/~vpap/i-footman/*

Football Players Ontology

The Football Player Ontology (FPO) has been developed in Ontology Web Language (OWL) [2] and, in particular, the OWL-DL version. It is the first ontology, according to our knowledge, that focuses on the description of football players. FPO provides an extensive vocabulary referring to the various player characteristics, focusing on the features used by a manager in order to make a tactical decision, and the tactical instructions that a football player could follow. Some key concepts of the ontology concern the football players ("Football_Player"), the positions they can hold during a football match ("Position") and the abilities of the footballers ("Ability"). Each ability that describes a certain player is assigned a value denoting its respective quality. This fact facilitates the definition of complex concepts through conditions of equivalence. For instance, the following statement defines the concept of "creative" middlefielders:

$$\text{fpo:CreativeMiddlefielder} \equiv (\text{fpo:hasPassing.GoodAbility} \sqcup \text{fpo:hasPassing.VeryGoodAbility}) \sqcap \text{fpo:playsInPosition.Middlefielder} \quad (1)$$

Football Teams Ontology

The Football Teams Ontology (FTO) provides the terms for describing the main features of football teams and the tactical guidelines they could follow. This vocabulary is also expressed in terms of OWL-DL and is strongly related to the FPO. Specifically, the FTO reuses the FPO vocabulary extending it properly.

The FTO terms could be distinguished to three parts. Firstly, the ontology defines some generic team features (e.g., the players of a team). Secondly, the ontology takes advantage of DLs in order to classify the various team instances into certain categories (e.g., teams that attack from the wings). Finally, the FTO models the various tactical instructions allowing the execution of rules that will follow.

Rules

The rules constitute the declarative part of the knowledge base and are expressed in terms of the Semantic Web Rule Language (SWRL) [3]. The basic idea behind the adoption of SWRL was the combination of ontologies and rules in the same logical language. The rules reuse the vocabulary provided by the FPO and FTO in order to define more complex relationships and their structure was based on the knowledge acquired by the experts. They can also be distinguished in four main categories[2]:

1. Identification Rules. These rules aim to identify the weaknesses and the advantages of the opponent. They are mainly based on the opponent's team formation and the features of players in order to deduce the capabilities of the opponent. For instance, the following SWRL rule expresses the knowledge that a team plays well the counter attack when two or more of its offensive players are quick[3]:

[2] For space limitation reasons, a simplified version of the rules is presented here. The complete form of rules can be found online in *http://www.di.uoa.gr/~vpap/i-footman/rules.owl*.

[3] QuickOffensivePlayer is an FPO concept defined through necessary and sufficient conditions.

$$\text{fto:hasStartingPlayer}(?t1,?p1) \wedge \text{fto:hasStartingPlayer}(?t1,?p2) \wedge \text{fpo:QuickOffensivePlayer}(?p1) \wedge \text{fpo:QuickOffensivePlayer}(?p2) \rightarrow \text{fto:dangerousAtCounterAttack}(?t1,\text{true}). \quad (2)$$

2. Formation Rules. They are responsible for specifying the tactical formation that the team will follow during a match. In particular, the number of defenders, middlefielders and attackers is determined as well as the positions that they should cover. The following rule describes a case where three central defenders are used:

$$\text{fto:myTeamPlaysAgainst}(?t1,?t2) \wedge \text{fto:TeamWith3CentralDefenders}(?t2) \wedge \text{fto:TeamWith3CentralPlayers}(?t2) \wedge \text{fto:TeamWithSideMFs}(?t2) \wedge \text{fto:TeamWith2Attackers}(?t2) \rightarrow \text{fto:playsWith3CentralDefenders}(?t1, \text{true}). \quad (3)$$

3. Player Selection Rules. They make use of players' features and tactical formation of the teams. i-footman proposes the appropriate players to form the team's composition according to the classification that has been already completed through the ontology reasoning processes. A typical player selection rule follows:

$$\text{fto:myTeamPlaysAgainst}(?t1,?t2) \wedge \text{fpo:playsWith1Striker}(?t1) \wedge \text{fpo:GoodStriker}(?p1) \wedge \text{fpo:isMemberOf}(?p1,?t1) \rightarrow \text{fpo:isSuggestedTo}(?p1,?t1). \quad (4)$$

4. Tactical Instructions Rules. They specify the tactical instructions suggested by the system. These rules take advantage of the opponent weaknesses and strengths specified by the identification rules and information coming from formation rules. The following rule denotes that if a team does not use side defenders then the opponent should identify this weakness and attack from the wings.

$$\text{fto:myTeamPlaysAgainst}(?t1,?t2) \wedge \text{fto:TeamWithNoBacks}(?t2) \wedge \text{fto:TeamWithWingers}(?t1) \rightarrow \text{fto:shouldAttackFromTheWings}(?t1, \text{true}). \quad (5)$$

3 Evaluation

Since no actual data and statistics were available during the development of i-footman, the evaluation was accomplished through simulations. Specifically, the simulation is based on two scenarios and takes advantage of two computer games that focus on the tactical management of football teams: the Championship Manager 2008 (Eidos) and Football Manager 2008 (Sports Interactive). Such computer software simulate a football match according to the tactical instructions that have been given as input to both teams and generates a final result for that game. Moreover, the platforms provided some players' and teams' statistics that have been inserted to the ontologies.

Regarding the first evaluation scenario, two teams with similar ratings (according to the evaluation provided by each platform) were selected. Specifically, Barcelona FC (Spain) was guided by i-footman while the computer handled the team of Real Madrid FC (Spain). 40 games were simulated in each platform (80 in total). The computer handled both teams in the first 20 games (in each platform) with no external interference while i-footman managed the team of Barcelona in the next 20 games.

The match results of the first scenario are presented in Fig. 2. In a total of 40 matches without the intervention of i-footman, Barcelona won 14 times, Real Madrid won 16 times and 10 games came to draw. Furthermore, Barcelona scored 45 goals while Real Madrid scored 61 goals. Afterwards, the same number of matches was executed with i-footman controlling Barcelona and the results seemed to be in favour of Barcelona. Although the number of Barcelona's wins did not increased substantially (only by 1), the number of losses decreased by 50% (8 instead of 16). Furthermore, Barcelona scored 51 times (instead of 45) while opponent scored 36 (instead of 61). This means that the recommendations of i-footman lead to significant improvement of the team performance.

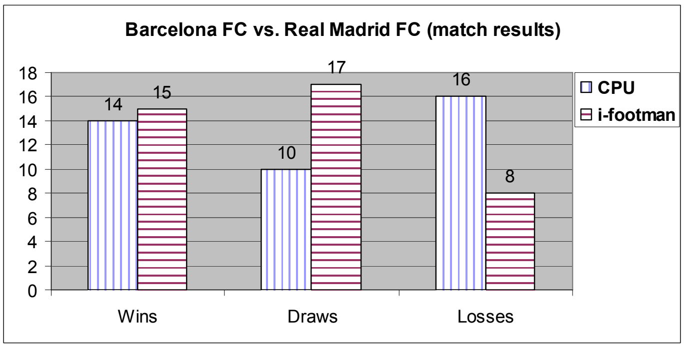

Fig. 2. Match results of the first scenario

The second scenario concerned the evaluation of i-footman when playing against an opponent with better ratings than the one managed by the system. Specifically, Olympiacos FC (Greece) was handled by the system and played against Real Madrid. The results of this scenario were very similar to the former with a minor improvement of the total number of wins accomplished by i-footman.

Generally, i-footman seems to perform well in such simulation environments. Although the performance of the user's team does not improve substantially, the adoption of i-footman seems to tackle the opponent's performance successfully. This stems from the fact that both goals and wins of the opponent's team are obviously decreased. The large number of rules that refer to the defending strategy of the team may lead to that. Specifically, the tactical formation and composition of the team are mainly adapted to the advantages and less to the weaknesses of the opponent's team. This could be improved by extending and modifying the rules of the knowledge base (possibly through interviews of more domain experts).

Regarding the time performance of the framework, the expected response time was 7741ms (as measured on a typical Desktop PC). Such time seems reasonable since it includes all the reasoning processes (i.e. hierarchy classification, instance checking of FPO and FTO ontologies and rules execution) that were performed.

4 Conclusions and Future Work

We have presented a knowledge-based framework able to support decision making in the context of football. More precisely, the paper focuses on the architecture of i-footman, its application models and the simulation results derived during the evaluation process. The main issue that has been identified during development was the lack of an integrated reasoning framework capable of handling ontologies and rules. Today, there is no efficient reasoning module that can reason over both formalisms seamlessly. Hence, the developer has to perform ontological reasoning and provide the results as input to the rule engine and vice versa in order to achieve effective knowledge management.

As described, i-footman was designed to facilitate the addition of possible extensions regarding its functionality by modifying the knowledge used to describe the application domain of football. This process would be facilitated by the exploitation of learning techniques that target to automate the generation of the declarative part of the knowledge base (i.e. the rules). This could be achieved either by accessing actual statistical data about players and teams or by taking the results that arise from the simulation platforms as real. Since no real data are available, the exploitation of learning algorithms over virtual data seems to be more feasible. Finally, more expressive knowledge representation languages that support fuzziness could be adopted in order to deal with knowledge uncertainty issues.

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