A modelling language for cooperative plans in highly dynamic domains

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A B S T R A C T

Cooperative behaviour is one of the challenges most pronounced in the RoboCup Middle Size League. Especially the dynamic nature of the domain, which calls for swift adaptation by each robot and the team as a whole, is a distinctive property of the league. The ability to establish highly responsive teamwork while facing unreliable communication and sensory noise is a key to successful soccer teams. Moreover, modelling such responsive, cooperative behaviour is difficult. In this work, we specify a novel model for cooperative behaviour geared towards highly dynamic domains, focussing on the language syntax and semantics. In our approach, agents estimate each other's decision and correct these estimations once they receive contradictory information. We provide a comprehensive approach for agent teamwork featuring intuitive modelling capabilities for multi-agent activities, abstractions over activities and agents, and a clear operational semantics. Moreover, we briefly present a graphical modeling tool for cooperative strategies, which is based directly on the theory laid out, together with a practical framework for executing said strategies. We show experimentally the responsiveness and coherence of the resulting team play.

1. Introduction

Robotic domains such as the Robocup Middle Size League are very dynamic in nature. In the case of the Robocup Middle Size League, soccer was chosen as a test-bed for robotics research. Soccer is a fast paced game, requiring the participants to make decisions in split seconds, while retaining an overall coherence in team play. Moreover, similar to human soccer players, current robots are unable to fully observe the whole state of the game. Both robotic and human players need to estimate the actual state of their surroundings and anticipate the dynamics of the situation.

In this paper we present a language to model cooperative actions of autonomous agents, A Language for Interactive Cooperative Agents (ALICA). The language was firstly discussed in [23], here, we will extend upon this description. We are targeting dynamic domains, where agents need to make swift and autonomous decisions, which cannot always be explicitly communicated beforehand. Taking such decisions bares the risk of degrading the level of coherence within a team. In our approach, this is compensated by the fact that each agent keeps track of its teammates and anticipates their decisions with respect to the common plan or strategy.

We explain our newly developed language for describing team plans, present a state-of-the-art modelling tool for this language, and show practical results obtained during the RoboCup World Championship 2009.

In the next section, we will present related work, focusing on theories and frameworks, which influenced ALICA. Section 3 will describe the formal background of ALICA in detail. The remainder of this paper is concerned with the practical application of the presented theory, starting with the introduction of an exchange format of ALICA language elements based on XMI [13] and an explanation of the layout of our runtime engine, which interprets ALICA programs and thus controls a robot, in Section 4. Section 5 describes a graphical editor for ALICA programs, implemented in the Eclipse framework [3]. Section 6 shows a practical example in the RoboCup domain, which is used and evaluated during the World Championship 2009 and discusses the results of this evaluation. Finally, Section 7 concludes the paper and hints at future work.

2. Related work

In this section, we discuss the most relevant related works regarding behaviour modelling theories and tools.

2.1. Behaviour modelling

Many research activities tackled the problem of describing agent behaviour and addressed the challenge to establish coherent teamwork of autonomous agents. As a result there exist several teamwork theories. One of them is the Joint Intentions Theory [17], founded on Belief, Desire, Intention (BDI) [4]. Within the BDI model, an agent typically chooses a subsets of its desires to