Research Abstract – Team AT Humboldt 2002

Joscha Bach, Ralf Berger, Birger Brunswiek, Hans-Dieter Burkhard, Michael Gollin, Kay Schröter, and Jan Wendler

Humboldt University of Berlin, Department of Computer Science
bach|berger|brunswie|hdb|gollin|kschroet|wendler@informatik.hu-berlin.de
http://www.ki.informatik.hu-berlin.de/RoboCup/index.shtml

Abstract. The agent concept of AT-Humboldt 2002 is based on a deliberative BDI architecture that generates and executes plans. This is done by dynamically building hierarchical option sequences and combining them with distributed roles. Because of the real-time demands of RoboCup, long-term deliberation and actual execution of intended options are taking place in independent passes, leading to a double pass architecture [1]. The developers can design the behavior of the agents using an XML based specification language [15].

1 Introduction

Our group's general research focus encompasses agent-oriented techniques, case-based reasoning, knowledge management, intelligent robotics, cognitive science and socionics. We investigate agent architectures and deliberation concepts that allow to build rational, flexible, dynamic and cooperative multi agent systems, with applications in e-commerce, medicine and industry [2],[3],[4].
We have found RoboCup to be an interesting and challenging domain for the development of new techniques [5],[6] and we participate in two leagues: in the simulation league (since 1997) [7],[8],[9] and in the Sony four-legged robots league. We are members of the DFG (German research foundation) programme "Cooperating teams of mobile robots in dynamic environments", with a particular focus on agent architectures [`http://ais.gmd.de/dfg-robocup/`]. A lot of our work in RoboCup is strongly linked to current work in the fields of our other research:

- Case Retrieval Nets have been developed as a means for efficient and flexible retrieval in Case Based Reasoning [10] and have been employed in several of our agent versions, for instance for self-localization and the kick skill [11],[12].
- Social modelling with multi agent systems is a subject to research in socionics [13],[4], and our team of agents is influenced from models of social roles developed within this domain. These roles find their application in the delegation of actions between agents.
- Our architecture represents a Belief-Desire-Intention approach. To go beyond emergent cooperative behavior, we are currently focusing on methods for long-term deliberation and the explicit modelling of cooperation. This is done by representing cooperative strategies as hierarchies of options [14].

In return ideas from soccer team development have often been fruitful for projects outside RoboCup, for instance in cognitive robotics and of course in education.

2 Approach

Our agents are structured along a BDI architecture. While 'beliefs' are determined by the current world model, including data about roles of other agents, 'desires' are given by game situations, role and status of the agent. These desires lead to the generation of plans according to pre-defined option hierarchies. Sub-plans that have been selected for execution amount to 'intentions'.

2.1 Team AT Humboldt

The AT-Humboldt 2002 team employs separated threads for deliberation and execution of plans. Plans consist of elementary options (parameterized skills that can be translated into sequences of action commands), which are grouped into sequences of higher-level options.
The definition of option hierarchies is done in the form of an explicit model, which is specified in an XML based language, read and parsed at agent start-up and transformed into C++ objects.
Roles are used as a tool to group behaviors, i.e. different behavioral strategies are assigned to roles and implemented using a different option hierarchy. Thus, roles amount to different scripts, which are intertwined with the scripts of team mates. Knowing the role of other agents, it is possible to determine their behavior. By assigning roles carefully, individual agents may behave like actors in a play and perform arbitrary maneuvers.
With the introduction of heterogeneous players, it makes sense to assign tasks to individual agents with respect to their individual abilities. This is also done by tailoring roles to agents. All roles include some default behavior to make sure that agents do not completely fail if communication does not work or unexpected things happen. AT-Humboldt 2002 currently makes use of the coach to determine the features of heterogeneous players. Further integration of the coach is planned.

2.2 Earlier Work

While AT-Humboldt 2002 has been rewritten from scratch, we are using experiences from earlier projects, especially for data structures, world modeling, self localization etc. The option architecture of our earlier agents is flat: for instance AT-Humboldt 2000 reviews a list of possible (elementary) options in every simulation step and executes the first possible option in the list. The results of the analysis are stored to allow faster deliberation and persistent execution. In 2001, this was enhanced by a more complex model of intentions and the introduction of roles. The main difference to our earlier work (and also to other approaches known to us in the RoboCup domain) consists in the introduction of dynamic, hierarchical plans.

3 The Double-Pass Architecture

Architectures for behavior control in dynamic real-time environments have to cope with several requirements:

- Long term planning should take place independently of real time constraints. Thus, long term plans must be stable against small changes of the world.
- The active low-level behaviors must adapt to changes (least commitment).
- It is possible that minute changes in the world create different demands to agent behavior, so different plan-branches should be prepared.

The main idea behind the "double-pass architecture" is a hierarchical tree of possible behaviors at different levels of abstraction. In contrast to other approaches the control flow is directed by a deliberator and an executor, that are strictly seperated.
The root of the tree is called Role, describing main modes of behavior and communication policies. By changing roles collectively, the team can easily switch into a constellation that favors certain maneuvers.
The actual agent control works in two phases: Actions are chosen by the deliberator according to the respective goal and the situation at hand and pre-arranged into option-sequences for long-term behavior. The deliberator has to prepare new activation paths that are later to be executed by the agent, and it has to ensure the validity and profitableness of already established pathes.
The execution pass is triggered by a timer and carries through the activation path laid out by the deliberator. Having the executor browsing through the complete path makes it possible not to test all conditions at the level of the elementary conditions, which is a major disadvantage of standard layered architectures. This way, options can be modular and reused at different positions of the option tree.
The split of the architecture into a real–time execution layer and an asynchronous deliberator to prepare and monitor long-term behavior makes it possible to follow persistent strategies, which can be capitalized on for cooperation between agents and behavior modeling/evaluation by the developers.

3.1 Current State of the Implementation

The implementation of the double-pass architecture based on a behavior description is still in its prototypic stage. By now we set up the architecture with a number of basic scripts that are meant to cover standard maneuvers of robotic soccer, such as double-passing, wing-changes or offside-traps. While implementation of the general framework is finished, some minor details and the actual behavior specification are still subject of discussion.
The architecture is employed both in the robot soccer simulation league as well as in the Sony four–legged robot league, where it is going to replace the current behavior module.

4 Limitations and Outlook

Our work follows two main purposes: to develop new concepts for agent architectures, and to use RoboCup in the practical education of students as part of a multi-agent systems course. This has a downside in that it tends to lead to relatively poor basic skills of the agent (i.e. passing, dribbling, ball interception etc.). Over the last years, there was a general lack of fine-tuning in our agents which resulted in only average results at competitions. However, they still display a solid performance.
The decision which option to select in a given situation is currently made according to a fixed search strategy consisting of simple simulation and heuristics. Generally, it is desirable to learn decision criteria rather than to specify them explicitly. A part problem consists in representing world model data at a more abstract level of description, where the structures of representation vary according to what has to be evaluated. Another untackled yet fascinating problem is meta-planning, the evaluation and construction of deliberation strategies by the agent, which opens up an interesting avenue for further work.

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The references in the Research Abstract are related to the text.
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