Small Robots League, Team *VUB-AI-lab*, pages 81–84
http://www.ep.liu.se/ea/cis/1999/006/14/

VUB AI-lab team

VUB-AI-lab

Andreas Birk, Thomas Walle, Tony Belpaeme, Holger Kenn

AB, TW, TB, HK: Vrije Universiteit Brussel (VUB), AI-lab

Abstract.

Abstract

The VUB AI-lab team is mainly interested in the two loosely linked aspects of on-board control and heterogeneity. One major effort for forstering both aspects within RoboCup's small robots league is our development of a so-to-say robot construction-kit, allowing to implement a wide range of players with on-board control. For the '99 competition, the existing RoboCube controller-hardware has been further improved. In addition, some solid and precise mechanical building-blocks were developed, which can easily be mounted on differently shaped bottom-plates. On top of these engineering efforts, we report here a computational inexpensive but efficient algorithm for motion-control, including obstacle avoidance. Furthermore, we shortly address the issue of increased diffulties of coordinating so-to-say multiple teams due to the possible variations based on heterogeneity. Operational semantics based on abstract data-types and patter matching capabilities can be a way out of this problem.

1 Introduction

As we already pointed out in a contribution to RoboCup'98 [BWB+98], RoboCup is not laid out as a single event, but as a long-term process where robots, concepts, and teams co-evolve through iterated competitions. Within this process, we belief that two loosely linked aspects are especially important, namely the exploitation of heterogeneous systems and on-board control.

Heterogeneity is an almost kind of "natural" aspect for soccer systems. Body aspects as well a behavioral aspects are typically linked to trade-offs like for example speed versus strength. Thus, there are no generally optimal players, but only suited players for certain situations. Heterogeinity of a team, including a rich set of players on the bench, allows to adapt the set of players on the field by substitutions much like in real soccer. Furthermore, diversity in the body features and behavioral aspects of the players plays an important role in the co-evolutionary process of iterated competitions, leading to constantly improving teams and scientific insights.

On-board control is in so far linked to heterogeneity as it is desirable to have a kind of construction-kit, which allows to design a wide range of different types of robot-players, including an easy implementation and change of motor and mechanical aspects as well as sensor systems. When using "string-puppets", i.e., radio-controlled toy-cars with off-board computation on a host, a support of a wide range of motor and sensor features is severely restricted due to bandwidth limitations. But there is an additional reason for the significance of on-board control within the RoboCup framework. Namely, RoboCup is an ideal testbed for the investigation of Autonomous Systems, i.e., networked embedded devices with physical interfaces in form of sensors and motors as well as stand-alone capabilities. This type of devices has in shortest time grown into a significant market and it will be one of the key technologies of the new millenium.

2 The body aspects

For RoboCup'98, the VUB AI-lab team focussed on the development of a suited hardware architecture, which allows to implement a wide range of different robots. The basic features of this so-called RoboCube-system are described in [BKW98]. For RoboCup'99, the system is further improved and extended.

In addition to improvements on the electronics and computational side, the mechanical approach for our robots has completely changed. Instead of using mechanical toy-kits like LEGO^{TM} as we did in the previous year, we developed a solid but still flexible solution based on metal components.

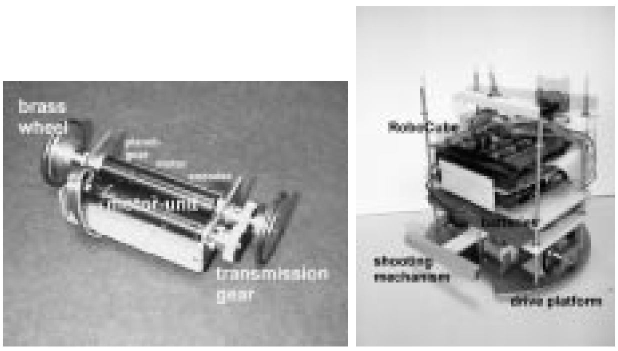

Figure 1: The drive unit (left) as a mechanical building-block, which can be integrated into several different robots like e.g. the one shown on the right.

Keeping the basic philosophy of construction-kits, a "universal" building block is used for the drive (figure 1, left side) of the robots. The drive can be easily mounted onto differently shaped metal bottom-plates, forming the basis for different body-forms like e.g. the one shown in figure 1 on the right side. The motor-units in the drive exist with different ratios for the planetary gears, such that several trade-offs for speed versus torque are possible.

Other components, like e.g. shooting-mechanisms and the RoboCube, are added to the bottom-plate in a piled-stack-approach, i.e., four threaded rods allow to attach several layers of supporting plates.

3 On-board control

Based on these engineering efforts, it is now possible to implement quite some different types of robots with on-board control capabilitities. But to actually use them, two major issues have to be solved, namely the software implementation of on-board control with the limited computational means of the RoboCube and the coordination of the so-to-say multiple teams due to the possible variations based on heterogeneity.

In this section, the on-board control is discussed. For a general discussion of this issue, the interested reader is referred to [BKW99].

24	23	22	21	20	19	18	17	16	15	14	15	16	17	18
23	22	21	20	19	18	17	16	15	14	13	14	15	16	17
22	21	20	19	18	17	16	15	14	13	12	13	14	15	16
21	20	19	18	17	16	15	14	13	12	11	12	13	14	15
20	19	18	17	16	15	14	13	12	11	10	11	12	13	14
19	18	17	16	15	14	13	12	11	10	9	10	11	12	13
18	17	16	15	14	13	12	11	10	9	8	9	10	11	12
19	18	17	16	[X]	[X]	[X]	[X]	[X]	8	7	8	9	10	11
18	17	16	17	[X]	[X]	[X]	[X]	[X]	7	6	7	8	9	10
17	16	15	16	[X]	[X]	[X]	[X]	[X]	6	5	6	7	8	9
16	15	14	15	[X]	[X]	[X]	[X]	[X]	5	4	5	6	7	8
15	14	13	14	[X]	[X]	[X]	[X]	[X]	4	3	4	5	6	7
14	13	12	[X]	[X]	[X]	6	5	4	3	2	3	4	[X]	[X]
13	12	11	[X]	[X]	[X]	5	4	3	2	1	2	3	[X]	[X]
12	11	10	[X]	[X]	[X]	4	3	2	1	0	1	2	[X]	[X]
11	10	9	8	7	6	5	4	3	2	1	2	3	4	5
12	11	10	9	8	7	6	5	4	3	2	3	4	5	6
13	12	11	10	9	8	7	6	5	4	3	4	5	6	7
14	13	12	11	10	9	8	7	6	5	4	5	6	7	8
15	14	13	12	11	10	9	8	7	6	5	6	7	8	9

Figure 2: A kind of potential field for motion-control based on Manhattan distances. Each cell in the grid shows the distance to a destination (marked accordingly with Zero) while avoiding obstacles.

For the RoboCup'99 team, we significantly increased the amount of processing, which is actually taking place on the robots. In addition to the basic control of driving and shooting, the complete motion-planning and simple strategies are computed on the robots themselves.

Especially the motion-planning, including obstacle-avoidance, is with most common approaches rather computationally expensive. We developed a kind of potential-field algorithm based on Manhattan-distances. Given a destination and a set of abitrary obstacles, the algorithm computes for each cell of a grid the distance to the destination while avoiding the obstacles (figure 2). Thus, the cells can be used as gradients to guide the robot. The algorithm is very fast, namely linear in the number of cells.

4 Team-coordination and heterogeneity

As mentioned before, heterogeneity is an important feature for soccer with human as much as with robot players. It is the main basis for adaptation of a team, let it be to different opponent teams within a tournament, or to the general progress of a particular game, or to very momentary situations. Heterogeneity within soccer can range from high-level different roles of players in a team like forward or defender, down to different body features covering a wide-range of physical trade-offs like e.g. speed versus torque.

Straight-forward approaches to team coordination with the expressive power of finite state automata are doomed to fail under such a wide-ranges of heterogeneity due to the combinatorial explosion of states. Therefore, we investigate coordination schemes based on operational semantics, which allow an extremely compact and modular way of specifying team behaviors. One step in this direction is the *Protocol Operational Semantics (POS)*, an interaction protocol based on abstract data-types and patter matching capabilities. So far, it has only been tested in simulations, but the results are very encouraging. A detailed desciprtion can be found in [OBK99].

5 Conclusion and Acknowledgments

The paper describes the RoboCup'99 small robots league team of the VUB AI-lab. Our main interest is in on-board control and heterogeneous agents.

The VUB AI-Lab team thanks Sanders Birnie BV as supplier and Maxon Motors as manufacturer for sponsoring our motor-units. Andreas Birk is a research fellow of the Flemish Intitution for Applied Research (IWT); research on RoboCup is partially financed within this framework (OZM980252). Research on the RoboCube is partially funded with a TMR-grant for Thomas Walle (ERB4001GT965154). Tony Belpaeme is a Research Assistant of the Fund for Scientific Research - Flanders (Belgium) (F.W.O.).

References

[BKW98] Andreas Birk, Holger Kenn, and Thomas Walle. Robocube: an "universal" "special-purpose" hardware for the robocup small robots league. In *4th International Symposium on Distributed Autonomous Robotic Systems*. Springer, 1998.

[BKW99] Andreas Birk, Holger Kenn, and Thomas Walle. From string-puppets to autonomous systems: On the role of on-board control in the small robots league. Technical Report under review, Vrije Universiteit Brussel, AI-Laboratory, 1999.

[BWB+98] Andreas Birk, Thomas Walle, Tony Belpaeme, Johan Parent, Tom De Vlaminck, and Holger Kenn. The small league robocup team of the vub ai-lab. In *Proc. of The Second International Workshop on RoboCup*. Springer, 1998.

[OBK99] Pierre-Yves Oudeyer, Andreas Birk, and Jean-Luc Koning. Interaction protocols with operational semantics and the coordination of heterogeneous soccer-robots. Technical Report under review, Vrije Universiteit Brussel, AI-Laboratory, 1999.