The Ulm Sparrows 99

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1 Introduction

THE ULM SPARROWS ROBOCUP team was initiated in early 1998. Among the goals of the team effort are to investigate methods for skill learning, adaptive spatial modeling, and emergent multiagent cooperation [1]. We develop both a middle-size robot league *and* a simulation league team. Based mostly on equipment and technology available in our robot lab, we implemented a first version of both teams for ROBOCUP-98 in order to gain practical experience in a major tournament. Based on the these experiences, we made significant progress in our team effort in several areas: we designed new robot hardware, extended our vision processing capabilities and implemented a revised and more complete version of our soccer agent software architecture. In particular, we added Monte Carlo localization techniques to our robots, enhanced environment modeling, and started to apply reinforcement learning techniques to improve basic playing skills.

These improvements allowed our simulation team to consistently beat the qualification teams back home, e.g. the ROBOCUP-97 simulation champion AT Humboldt. In the ROBOCUP-99 simulation tournament, however, we had two very strong teams (the later champion CMUnited-99 and Headless Chickens) in our group and suffered some ugly defeats. Things went better for our robot team, although we still had to debug various hardware and software problems even during the tournament. In a middle size tournament with 20 teams playing the preliminaries in three groups, we finished second in our group and qualified directly for the playoffs. We then lost in our quarterfinal match against the Italian team, which advanced to the final and finished second overall. Altogether, we made substantial progress this year and laid a more solid foundation for future team development.

2 Team Development

Team Leader: Gerhard Kraetzschmar
Team Members: (Graduate students are in a M.S. program.)

- Stefan Sablatnög, PhD student, simulation team coordinator

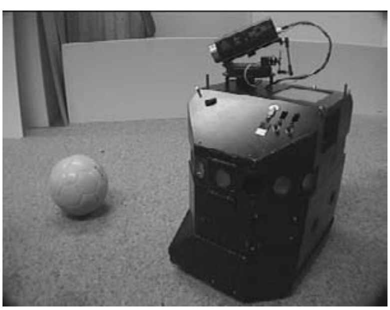
M. Veloso, E. Pagello, and H. Kitano (Eds.): RoboCup-99, LNAI 1856, pp. 638–641, 2000.

– Stefan Enderle, PhD student, robot team coordinator
– Mark Dettinger, Thomas Boß, Mohammed Livani, all PhD students
– Michael Dietz, technician
– Jan Giebel, Urban Meis, Heiko Folkerts, Alexander Neubeck, Peter Schaeffer, Marcus Ritter, Hans Braxmeier, Dominik Maschke, all graduate student students
– Gerhard Kraetzschmar, research assistant professor
– Jörg Kaiser and Günther Palm, professors.

Web page `http://smart.informatik.uni-ulm.de/SPARROWS`

3 Robots

For RoboCup-99, we designed a new, modular robot which currently consists of five modules (see Figure 1): base, kicker, sonar, CPU, and camera. The latter four are common to all players. Only for the base module, which provides mobility, different designs are used for field players and the goalie: field players have a standard differential drive, while the goalie has a special four-wheel drive permitting very fast left/right movements.



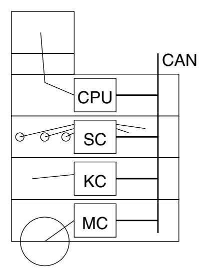


Fig. 1. A photo of the Sparrow 99 robot and a sketch of its hardware architecture. MC=motor controller, KC=kicker controller, SC=sonar controller, CPU=PC104+ with PCI framegrabber.

The design of our computer hardware for the robots follows the *smart device architecture* approach. It fosters modular, distributed designs by bringing computation closer to the data. We combine sensors and actuators with microcontrollers. These *smart sensors/actuators* perform local computation on data and thereby reduce communication and computation load on the central CPU. These *smart devices* communicate via a CAN bus with each other and the main CPU (see Figure 1). Modules can be connected using only four lines: two for power supply, and two for the CAN bus.

4 Software Architecture

We continued the implementation of a *common soccer agent software architecture* [1] (see Fig. 2) for both the simulation and the real robot teams. This year we

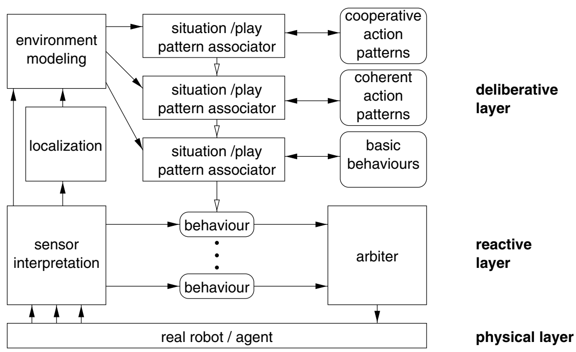


Fig. 2. The Ulm Sparrows soccer agent architecture

provided a C++ software library that allows to quickly implement and modify the reactive layer of the architecture. It provides behavior and arbiter classes, which are easy to instantiate and ensure safe execution of behaviors and arbiters as parallel threads. A graphical policy editor can be used to specify temporal sequences of behavior sets based on events and signals; it automatically generates program code.

5 Perception

Our new robot hardware now permits us to grab frames faster and with higher resolution. We extended our behavior-based vision architecture with line-detection routines in addition to color blob trackers, and can now detect the ball, both goals, and the corners quite robustly.

6 World Model

Our soccer agents apply multi-layered spatial representations for modeling the environment. Currently, a two-layer approach that is derived and adapted from the Dynamo spatial representation architecture (see [2]) developed in the SMART project is employed. The lower layer consists of an *egocentric feature map* representation. Relevant features include position and distance of the ball, the goals, and field landmarks. The egocentric representation is mainly used by low-level behaviors for rapid action selection.

The upper layer of the environment model is an *allocentric* spatial representation, which is constructed and maintained by integrating over time information present in the egocentric representation.

7 Skills

As demonstrated very convincingly e.g. by CMUnited-98, it is absolutely necessary to provide robust low level behaviours. Although behaviors can be handcrafted, this is a very tedious process that must possibly be redone every time some system parameter changes. Such parameter changes have occurred almost every year in both leagues we compete in, e.g. in the soccer server the size of the physical agent and stamina model parameters have been changed, as well as the field size and lighting conditions in the middle size league. All our behaviors used in competitions so far have been hand-crafted, but we have started to apply reinforcement learning techniques to this problem. Preliminary results are quite encouraging and we will extent our efforts in this area.

8 Strategy

Our decision to **not use** communication between players during games is quite unique. We also focus on building strong individual players first before seriously pursueing cooperative team play. Our approach builds upon strong situation assessment capabilities and a broad reportoire of basic skills (behaviors). Decision making is then the association and instantiation of the right set of behaviors with particular situations. Cooperative team play will be a natural extension. If it occurs, it will be emergent behavior, which arises when two or more players independently of each other, but in temporal synchrony classify a game situation and their role in it in a consistent manner.

9 Conclusions

The Ulm Sparrows team follows the lines of research set out in our initial team description paper [1]. We have made substantial progress and performed well in RoboCup-99. Our plans for the future focus on improving our software in almost all areas, in particular for situation assessment and skill learning.

References

1. Gerhard K. Kraetzschmar, Stefan Enderle, Stefan Sablatnög, and other. The Ulm Sparrows: Research into sensorimotor integration, agency, learning, and multiagent cooperation. In Minoru Asada, editor, *RoboCup-98*, volume TBD of *Lecture Notes in Artificial Intelligence*. Springer, 1999. to appear.
2. Gerhard K. Kraetzschmar, Stefan Sablatnög, Stefan Enderle, and Günther Palm. Application of neurosymbolic integration of environment modeling in mobile robots. In Stefan Wermter and Ron Sun, editors, *Hzbrid Neural Symbolic Integration*, volume TBD of *Lecture Notes in Artificial Intelligence*. Springer, 1999. to appear.