The Ulm Sparrows 2001

Hans Utz, Dominik Maschke, Alexander Neubeck, Peter Schaeffer, Marcus Ritter, Philip Baer, Ingmar Baetge, Jan Fischer, Roland Holzer, Markus Lauer, Jan Lindenmair, Alexander Reisser, Florian Sterk, Günther Palm, and Gerhard Kraetzschmar

University of Ulm, Neural Information Procssing,
James-Franck-Ring, 89069 Ulm, Germany

1 Introduction

The Ulm Sparrows team is an student-oriented, interdisciplinary research effort at the University of Ulm. The team is active in both the simulation and the middle-size league, but simulation efforts are targeted towards supporting the middle-size league robot team. We competed in the RoboCup World Championships in Paris (1998) [5] and Stockholm (1999, quarterfinals) [7], the European RoboCup Championships in Amsterdam (2000, semifinals) [4], plus a number of national events in Germany. For time and budget constraints, we could not participate in Melbourne in 2000.

Due to its strong foundation in student activity, the team was facing a major overhaul of its personnel in the past two years. Except for two undergraduates, all former team members graduated or finished their Ph.Ds. and left the team. However, we could attract a number of young, dedicated, and promising students, and with Hans Utz we found a new first-year Ph.D. student who will coach the robot team. In addition, we made progress in ensuring continuing team support by successfully applying to research funding in the Priority Programme of the German Research Foundation (DFG).

This paper describes some early results of the newly formed team and some promising proofs of concept of The Ulm Sparrows Robot Team 2001.

2 Team Development

The Ulm Sparrows are mainly a student project driven by the motivation and skills of our students.

Team Leader: Gerhard Kraetzschmar, Günther Palm
Team Coach: Hans Utz
Team Members: Philip Baer, Ingmar Baetge, Markus Lauer, Jan Fischer, Roland Holzer, Jan Lindenmair, Dominik Maschke, Alexander Neubeck, Alexander Reisser, Peter Schaeffer, Florian Sterk

3 Sensory and Actuatory Skills

In 1999, we introduced a new robot hardware platform, the *Sparrow-99* soccer robot, which was developed in our department. Two *Sparrow-99* robots are shown in 1. The *Sparrow-99* is a differential drive robot, equipped with sonar, a camera mounted on a pan-tilt unit and a pneumatic kicker. The computational power consists of a PC/104 computer, and, attached to it via CAN-Bus, a C167 controller for low-level control tasks (motors, odometry etc.). The hardware platform basically remained the same for the 2001 RoboCup team. However, we carefully extended our robot design to overcome some deficiencies that we discovered in past competitions.

Fig. 1. Two Sparrows-99 robots.

Since the speed of the robots became a more important aspect in tournaments, we improved our low-level control software, in order to achieve higher speeds, better traction control, and more reliable odometry. Our robots also received new, more powerful CPUs (PIII 700), which allow for more sophisticated vision processing, in order to match the requirements imposed by increased robot speed.

We also installed lightweight cameras with a wider view angle, in order to simplify the pan-tilt unit. In fact, due to the wider view angle, it is not any more necessary to use the tilt capability, which simplifies various steps in our image procssing routines. The new setup still allows us to study active vision problems introduced by the base-orientation independent viewing angle.

New hardware components include infrared distance sensors and radio ethernet cards. The infrared sensors have been added in order to study sensor fusion (of vision and IR) for ball handling and to allow a more accurate kicking. The wireless LAN allows the explicit communication between the individual robots and enables us to build powerful logging and monitoring facilities.

4 Research Interest

The research interests of The Ulm Sparrows include robot control architectures, sensor fusion, world modeling, and learning and adaptivity. The latter two are the focus of our project funded by the DFG Priority Programme. Core issues are learning of behaviors, situation classification, the association of situation and action, and the integration of learning functionality on various levels of abstraction in the robot control software. However, this project is just about to start, and work so far concentrated on laying the foundations.

4.1 Implementation Framework

We ported our distributed robot control software platform Miro (Middleware for Robots) [3] to the *Sparrow-99* robot. Miro utilizes the CORBA [6] standard and multiplatform libraries such as ACE and Qt to meet the needs of developing distributed software for (multi)robot scenarios. Miro provides interoperability and independence of specific robot platforms, communication protocols, operating systems, and programming languages. With Miro, we established a common implementation platform for all robots used within our lab, enabling researchers to easily evaluate their work on multiple platforms and within multiple scenarios. Miro is currently available under GPL for the B21 (pre-rFLEX) robot by RWI, the Pioneer-1 robot by ActivMedia, and the custom-built *Sparrow-99* robot.

For RoboCup, we investigate a distributed publisher/subscriber communications model based upon the CORBA Notification Service for sharing of pre-processed sensor information and features in a realtime scenario.

4.2 World Modeling

In 2000, we integrated a visual feature-based Monte-Carlo Localization (MCL) module. Compared to more common implementations of MCL, which are based on the evaluation of streams of laser scans, typically providing several hundred distance estimates up to ten times per second, our localization procedure used in RoboCup is based on sporadic visual features [2]. The RoboCup environment provides only few visual features that are easily detectable in the visual channel, like goal posts, corners, and lines, and due to camera geometry and specifications, there exist many postures where none of them is visible. To make localization more robust, we implemented visual distance estimators. Currently, we integrate feature vectors based on Hough transforms as well as further sensor modalities such as sonar.

We are redesigning our vision system in order to extract more visual features, such as shape. This additional information will allow for more reliable object recognition, leading to a more accurate dynamic world model.

The sensory information sharing framework enables us to incorporate sensory information gained by the other team members into the robot's world model without introducing dependencies between the players that jeopardize the autonomy of the individual soccer robot. It remains our main goal to build a team of robots as cooperating individuals, as it was described in [5]. Sensory features are distributed asynchronously via an event channel. If a player becomes unavailable, the lack of its sensory information might have an impact on the accuracy of the other robots world models, but not on their ability to make decisions.

4.3 Learning and Adaptive Behaviour

One of the most challenging tasks of autonomous mobile robots research is to enable robots to adapt to changes in the environment or the behavior of opponents. We consider adaptivity and learning to be prerequisites for true robot autonomy. Furthermore, we believe that both software platform and robot control architecture can hinder as well as ease the implementation of learning methods.

As a first step, we increased the runtime configurability of our software. We can tune every parameter of the robot soccer software dynamically. It is possible to specify (and alter on the fly) the entire behaviour engine. Secondly, the logging facilities introduced by the distributed control architecture enable us to acquire substantial amounts of data which can be used in offline training.

Looking at the RoboCup scenario, there are two different problem domains for learning and adaptivity. First, the RoboCup environment, like field dimensions, the colors and the robots individual configuration have very static properties. On the other hand, the game itself is highly dynamic and an even more hostile testbed for learning algorithms. Actually, adopting the robot's sensors and actuator to a specific field and the according lighting conditions of an individual tournament is an intermediate goal of our team. An interesting approach we successfully applied elsewhere [1] is to use the redundancy amongst different sensor modalities to adapt the model of a particular sensor. The long term goal is to master the learning challenges of the dynamic parts of the scenario. This is a far more sophisticated task, due to time constraints and limitations on the size of the sample set. But by solving the static part of the problem, we are confident to master the architectural challenges to investigate learning and adaptive behaviour within the very heart of the RoboCup challenge.

5 Summary

From a scientific perspective the RoboCup challenge is a perfect scenario to study various difficult problems in mobile robotics. We consider the research aspects together with the competitive aspects of the RoboCup challenge as highly synergetic.

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