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The CS Freiburg '99 Team

CS-Freiburg

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Abstract. *Based on the design of the CS Freiburg team, which participated sucessfully in Robocup'98, we developed a new team of robotic soccer players. While the hardware components and software architecture remained mainly unchanged, we invested some effort to improve the sensor data gathering and interpretation, the tactical components and the behavior-based control module. The main goal is to enable the players to act in a truly co-operative style which leads, for instance, to passing the ball from one player to another.*

1 Introduction

One of the interesting challenges in designing a successful robotic soccer team is the need to cover the entire loop from sensing over deliberation to acting. For example, successful ball passing needs good estimations of the position and velocity of the other players and the ball, projections into the future, planning ahead in order to create and exploit opportunities, and finally, it requires to act accordingly. If one of these abilities is hampered, ball passing will most probably fail.

One of our main goals in participating in RoboCup'99 is to enhance the design of our team *CS Freiburg* [5], which particpated successfully in RoboCup'98 [1], in a way such that the robots can intercept balls, pass balls and are more flexible in their role assignment. For this purpose, we worked on enhancing the sensor data gathering and sensor data interpretation components, redesigned the deliberation components, and refined the behavior-based control module. The hardware design is basically the same, save the replacement of the laser range finders by a new generation of more accurate devices and the replacement of the serial interfaces by faster ones. While we are aware of the fact that there are better alternatives for the basic platform and the kicker design, we decided to live with their limitations because they have proved to be reliable and robust enough for our purposes.

2 Sensor Data Gathering and Interpretation

The main sensors we use are *laser range finders* (now the new *LMS 200* range finders, which have an accuracy of 1cm) and the commercially available

Cognachrome vision system [5]. In the '98 team design we used only 5 laser scans and 8 frames per second, although the devices could give us 35 laser scans and up to 60 frames per second. Furthermore, we only had very inaccurate time stamps for the measurements.

In order to raise the data rate to the maximal possible rate, we are modifying the Cognachrome software and implementing new modules for gathering the data. Additionally, we started to use a real-time extension of Linux — *RTLinux* [2] — in order to cope with the high data rate from the laser range finder (500 KBaud) and to assign millisecond accurate time stamps to all measurements. Using the higher data rate, we expect to get much better estimates for the velocity of moving objects on the field. The additional processing time is bearable because our sensor interpretation methods work within a few milliseconds [6, 10, 8].

While self-localization based on the laser range finders give us very accurate and robust estimations of our own positions [6], the estimations of the positions of other players and the ball is not very accurate. For this reason, we now use model-based recognition techniques. For the laser range finder data, we use models of the players in order to get a better estimate of their positions. In the vision module, we use the shape of the ball to exclude false positives and to increase the accuracy of the estimation of the ball position. The latter improvement requires another modification of the Cognachrome software.

Finally, in order to compensate for the lack of stereo vision, we will use the entire group of robots to estimate the ball position more reliably and precisely than any single robot with monocular vision can do. The main idea in this approach is to use a combination of Markov localization (supporting robustness) and Kalman filtering (for accurateness) to combine the data from all robots – similar to an approach that has been proposed for self-localization [4].

3 Deliberation and Action Choice

Currently, the primary goal of a single player is simply to score a goal. Which action has to be performed to achieve this task is specified by the *local strategy* that is implemented as a linear decision tree in a decision module. For example, if the player is in possession of the ball and the way to the goal is free, a straight line from the robot's position to the goal is computed that maximizes distances to relevant obstacles. With maximum acceleration the robot follows this line and close to the goal the kicker mechanism is activated (*PlayBall* activity). But if the way to the goal is blocked, this activity is aborted and the robot returns to its home position.

Now the primary goal will be generalized, i.e., a player tries to perform actions that lead to more desirable game states. Of course, if a robot is in possession of the ball, then the *PlayBall* activity is still an option that will lead with high probability to a desirable game state. But when such an action is not possible, another option that is worth considering is to pass the ball to a team-mate who is in a better position.

As demonstrated in this example, the local strategy will be realized as a set of different options – which option to choose depends on a sophisticated evaluation of the world model and requires knowledge of the team-mates' positions, for example. One approach that appears to be promising seems to be the one by Dorer [3], which is an extension of Maes' action networks [7].

Without coordination, the actions of our players would interfere with each other. So we used a *global strategy* that, among others, assigned distinguished roles such as *left defender* or *right forward* to the players. These roles led to a static division of the field into slightly overlapping areas of competence. Under certain circumstances this static division turned out to be counter-productive. For example, if the left defender had moved close to the opponent's goal and then lost the ball, it had to return to its home position although it still might have been in a better attacking position then, say, the right forward. In such a case it is more practical to simply exchange roles. Another problem that arises when playing with three field players is a sending-off. If we play with two forwards and only one defender and the defender is sent off, it is vital that one of the forwards quickly takes the role of the defender.

The local strategy of a single player can be evaluated to a certain extent on an empty field or with static objects as opponents. In some cases, it might also be useful to see how a player performs against other players or with another player, so one could play 2 against 3. The evaluation of the global strategy of the whole team, however, requires both all robots to be operational at the same time and an opponent team. Since we do not have two teams at hand, we decided to develop a *RoboCup F2000 simulator* as a test bed for global strategies.

4 Behavior-Based Control

For playing an aesthetic and effective game of robotic soccer each soccer agent must be equipped with a set of basic behaviors. For last year's competition a small set of behaviors was implemented that consists of the *PlayBall* activity described above and other behaviors for tasks such as ball searching, moving to a certain position, ball approaching, or removing the ball from the field borders. Since our main goal for last year was to realize a reliable, robust and accurate perception module, we spent little time on the behaviors and so most of the implemented activities contain hand-tuned parameters that work well only in certain situations, e.g. when the ball is stationary.

Furthermore, we experienced that putting behaviors together in a sequence does not always lead to smooth results, for example in the sequence *MoveBehindBall, ApproachBall, PlayBall*. Here the robot first moves roughly behind the ball, approaches the ball carefully, and then moves and shoots the ball towards the opponent goal. The *MoveBehindBall* behavior stops the robot before switching to the next behavior in order to avoid hitting the ball before the *ApproachBall* behavior is activated. In some situations however, e.g. if the robot is in a good position behind the ball, *MoveBehindBall* does not need to slow down the robot, *ApproachBall* can be skipped and *PlayBall* can be called immediately for playing the ball towards the opponent goal. In order to address this problem, the sequential composition of behaviors has to be done in a context-dependent way based on information about how basic movements can interact.

As one of our goals for this year's competition is to further increase the level of play the soccer robots must have more options for playing the ball than simply using *PlayBall* for kicking the ball towards the opponent goal. Other teams in the small size leage, e.g. CMUnited [9], have successfully demonstrated that passing a ball to another team mate enables very aesthetic and effictive methods for goal scoring. Therefore besides improving the existing behaviors we are working on new behaviors that allow the interception of a moving ball.

5 Summary

Based on the hard- and software design of last year's team, we extend and refine the existing system in order to be able to play a more cooperative game. First of all, we work on refining the sensor interpretation in order to get better estimates for the ball position and velocity. Secondly, we redesign our strategic component to be able to create and exploit opportunities such as intercepting and passing the ball. Finally, we implement methods that based on the sensor interpretation and deliberation are actually able to exhibit such a behavior.

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