All Botz

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1 Introduction

This paper discusses some important features, which make the All Botz, the University of RoboCup team, a very unique team. In particular, the use of cheap hardware and the design of the video server.

Instead of custom built robots, the All Botz team consists of cheap remote controlled cars, which can be purchased at any toy store. The cars use coarse D-A converters to provide proportional steering and speed control. Cost is the main advantage of the All Botz; a standard team costs around $10,000 USD, compared to the $200 USD for the All Botz team.

Like most teams competing in the small sized league, the All Botz use a global vision system. However, there are a number of important differences between the All Botz and other teams. Firstly, it is not necessary that the camera is mounted overhead, but it can be mounted on any angle as long as the whole field can be viewed. Secondly, the toy cars are not modified, the video data is the *only* source of information for the agents.

Although disadvantaged by their cheap hardware, the All Botz achieved a respectable result.The All Botz had to play in a tough group, which included the two best teams in the world (Big Red from Cornell University, and Robotis from Korea).

In the first game, the All Botz lost 33:0 to Big Red. The biggest problem in this game was that our path planner took to long to formulate paths for our agents. Another problem was that the Big Red team, like all other teams, are much heavier and powerful than our robots, which meant that our robots were pushed around a lot.

In the next game, the All Botz faced Robotis. The Robotis team is a very exciting team to watch, since their robots move at a significantly faster than any other team. The All Botz lost 35:0 to Robotis. Our goalie made most of the first saves, but was not fast enough to clear the ball.

In our last game, we beat last year's third place finisher 5DPO 3:1. 5DPO is a difficult team to score against since their strategy is to cover the ball in their own half. Still, the All Botz dominated the game and territory. The only goal that 5DPO scored was due to an error of our goalie.

M. Veloso, E. Pagello, and H. Kitano (Eds.): RoboCup-99, LNAI 1856, pp. 653–656, 2000.
Springer-Verlag Berlin Heidelberg 2000

2 Team Development

Team Leader: Jacky Baltes
Team Members:

Jacky Baltes
- CITR, University of Auckland
- New Zealand
- Lecturer
- did attend the competition

Nicholas Hildreth
- CITR, University of Auckland
- New Zealand
- Graduate Student
- did attend the competition

David Maplesden
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3 Sensing

The most obvious difference between the All Botz and other teams is that the camera is looking at the playing field from the side rather than from directly overhead. This means that the All Botz are more flexible and can play under a wider range of conditions than other teams.

The side view introduces large perspective distortions in the image, which must be compensated for by the video server. This problem can be overcome by a sophisticated camera model and an accurate camera calibration. The All Botz use Tsai's camera calibration method that corrects for the radial distortion of the lens.

The calibration of this camera model requires a large set of calibration points, distributed across the playing field. Instead of using the points on the playing field itself (e.g., the corners and centre points), the All Botz use a calibration carpet (a duvet cover with a square pattern of white and blue square on it). Once a picture of the calibration carpet is taken, a program finds and sorts the squares in the image and assigns them real world coordinates. These mapped points are then used in the Tsai camera calibration to compute the parameters of the camera model.

This system has proven to be very robust. Camera calibration now takes less than 30 minutes and results are accurate to within one centimeter even at the far side of the image.

4 Communication

To improve robustness, the agents only use implicit communication to tell other agents about their goals and fall back on their autonomous behavior if communication fails.

The limitations of the car-like robot makes it very important that agents communicate. A lot of tasks that can easily be achieved by a single holonomic robot, such as clearing the ball by the goalie, can only be achieved efficiently by coordinating the activities of multiple agents using car-like robots.

Currently, the All Botz use two groups of players that communicate amongst each other: the two strikers, and the goalie/defender combo. The communication is similar in both groups and we will focus on the strikers in this paper.

Since it is impossible for our cars to move sideways, the strikers implement a "cycling" behavior. One striker moves in for a shot on goal, whereas the other striker moves into a position to wait for a rebound or to shoot at the goal next. Since we want to avoid having both strikers try to shoot at the goal at once, they need to communicate their intention. Both strikers evaluate their relative position to the ball and the goal. They then compute an estimate of the cost of a goal shot and the striker with the smaller cost will shoot at the goal whereas the other striker will move into the rebound position. The estimate of the goal shot cost is based on the holonomic path distance. After the first striker shoots at the goal, the world state will change and the striker waiting for the rebound will then start its attack run.

This scheme is augmented by: (a) implementing a hysteresis function for switching from goal shot to rebound to avoid oscillation, and (b) a time horizon scheme. The striker agent has only a limited time to show progress. If the goal shooter does not make progress towards the goal shot, because for example, it is being blocked by an opposing robot, the rebounder will attempt a goal shot. Once the rebounder is closer to the ball than the goal shooter, their roles will change and the striker will become the rebounder and it will attempt to move towards the rebound position.

5 Special Team Features

This section discusses the path planning problem and the problem of path following control for car-like robots and our solutions to these problems.

5.1 Car-like robot control

Controlling a car-like robot at high speeds with noisy vision data as the only source of information is a challenging and difficult problem.

Even though the non-holonomic control problem is more difficult than that of wheeled robots, the control of our agents is as good as that of other teams (with the exception of the Robotis team). The All Botz robots are controlled to a maximum speed of 1 m/s. However, the lack of local control means that the

All Botz system is much more robust. Schemes that use shaft encoders and stall detectors to augment the localization are unable to cope with rough terrain or slippery surfaces.

The state of the art in non-holonomic control was not sufficient to control car-like robots at high speeds. The All Botz developed a number of different control algorithms, the best ones being a look ahead controller and a controller that uses reinforcement learning to learn the control function. We believe that these are the best practical implementations of control for car-like robots in the world today.

5.2 Non-holonomic path planning

Efficient Path planning in highly dynamic environments is a difficult problem for holonomic vehicles. For car-like robot the problem is even worse.

Initially, the All Botz use a non-holonomic path planner, which is an extension of visibility graphs. This path planner performs well in a static environment, but its time complexity makes it unsuitable for dynamic environments.

Currently, the All Botz use an adaptive case-based path planning system. Instead of re-planning from scratch whenever an object moves in the domain, the path planner tries to adapt the current plan to match the new world state. The path planner uses the following set of adaptations for each path segment: translation, rotation, lengthening, shortening, change of turn radius, change from straight line to curve and vice versa, deletion, and insertion of a new path segment.

Another planner we are currently developing is a *any-time* path planner. The basic idea is that the agent can ask the planner for the best currently available plan. If given little time, the planner may return an incorrect or sub optimal plan. However, if given more time, the planner will eventually return the optimal plan.

6 Conclusion

For next year, the reinforcement learner will be enhanced to include look-ahead, which will allow us to control the cars at much higher speeds (2 - 3 m/s).

After emphasizing and finding scalable, practical solutions to the low level problems, such as control and path planning, we will focus more on the design of team strategies and agent coordination.

Currently, the agent architecture is being extended to include explicit communication. Also, the interaction between the controller and the path planner is being made more expressive. This allows the path planner to use short macro sequences (e.g., a quick kick followed by recovery) in the planning stage.

Also, currently, the strikers only attempt a direct shot on goal. The set of aims of the individual players will be extended to include passes, double plays, and give and go plays.

We hope that the addition of these strategic components will make the All Botz a team to be reckoned with in 2000. Our goal is to be among the best eight teams in the world.