Little Black Devils

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1 Introduction

There are four features that make make the Little Black Devils a very unique RoboCup team:

– The "robots" are based on Lego Mindstorms.
– The robots do not require coloured markers, manual tagging, or bar codes.
– The videoserver can view the playing field from any angle instead of only from directly overhead.

Instead of custom built robots, the Little Black Devils team consists of cheap Lego Mindstorms units, which are commercially available anywhere in the world. Cost is the main advantage of the Little Black Devils; a standard team costs around 10,000 USD, compared to the 1000 USD for the Little Black Devils team.

Most teams use some additional markers on the robot to determine the orientation of the robot. Furthermore, all other teams use either distinct markers or manual tagging to identify the robots. The Little Black Devils determine the orientation and identity of the robots using image processing and by correlating the movement commands with the observed behaviors of the robots.

Like most teams competing in the small sized league, the Little Black Devils use a global vision system. However, it is not necessary that the camera is mounted directly overhead: it can be mounted on any angle as long as the entire field can be viewed. A side view introduces large perspective distortions as well as occlusion problems that must be overcome.

2 Team Development

Team Leader: Jacky Baltes

Team Members:

John Anderson
- University of Manitoba
- Canada
- Team Leader
- attended

Jacky Baltes
- University of Manitoba
- Canada
- attended

Doug Cornelsen
- University of Manitoba
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- Team Leader
- attended

Terry Liu
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- attended

Brian Tanner
- University of Manitoba
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- Student
- did not attend

Ryan Wegner
- University of Manitoba
- Canada
- Student
- did not attend

Clint Stuart
- University of Manitoba
- Canada
- Student
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3 Hardware Platform

The Little Black Devils robots are based on Lego Mindstorms bricks, using a two wheel drive system. The Lego Minsdstorm RCX's that control these robots receive instructions via infrared from a controlling computer.

Since it is not possible for our robots 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.

4 Robot Orientation and Identity

Most teams use colored markers, manual tagging and bar codes to determine the orientation of their robots. These solutions have severe disadvantages since they do not scale up to larger teams and to more flexible camera positions. Also, since many different colours need to be determined or small features need to be detected, the resulting calibration is unstable. For example, even small changes in the lighting conditions often require a re-calibration.

It is difficult to distinguish between more than six different colours reliably over the whole playing field. Other teams spend a lot of time calibrating their colours. Bar codes or other geometric properties of the shapes are hard to distinguish under perspective distortion.

Based on these observations and our experiences in previous competitions, we started work on the design of a new video server. The design goals for the new video server were to provide a scalable, robust, flexible solution to the orientation and identification problem.

If we do not want to use additional patterns, then what else is there? The only information left is the image of the robot itself. So the goal was to design a videoserver that uses only a single marker ball and no other patterns on the robot.

Initially, we developed the videoserver Horus, which uses edge detection followed by a Hough transform to determine the orientation of the robot. This approach has worked well in RoboCup-2001.

Figure 1 shows the output for the three sample images given in Fig. 4. The contour of the robot is shown in black. As can be seen, using even a very coarse colour calibration, the edges of the robot can be traced accurately.

However, using the edges of the top of the robot does not use all available information. Thefore, our latest design of the videoserver (code named Doraemon) uses an artificial neural net to extract the orientation of the robot from a videoserver.

Figure 4 contains four zoomed views of our robots from our video camera. As can be seen, there is sufficient information in the images to extract the orientation of the robot from the image.

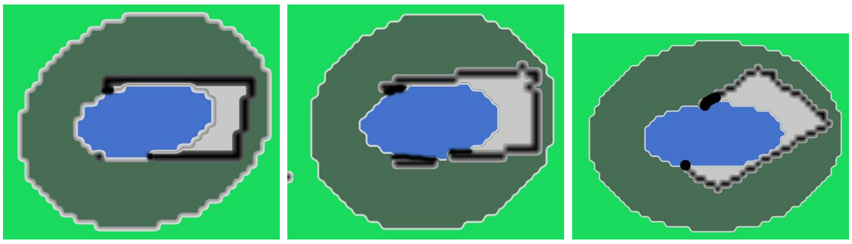

Fig. 1. The image of the robot after preprocessing. Pixels that are too far or too close are ignored. Pixels matching the colour of the top of the robot and pixels on the contour.

5 Identification of Robots

As mentioned previously, since all robots in our team look identical, the vision information is insufficient to identify them. Doraemon uses two additional sources of information to determine the identity.

Firstly, Doraemon predicts the motion of the robot and tracks it. Should the robot be found in the predicted position, its identity and its associated probability is not changed. If the robot is found in the neighborhood of the predicted position, its identity and confidence value are not changed.

Secondly, Doraemon observes the motion of the robot over a number of frames and assigns it one of seven states: not moving, forward left, forward straight, forward right, backwards left, backwards straight, and backwards right. The actual steering angle is not determined, so there is no difference between, for example, full left and gently left.

Doraemon listens to the communication between the clients and the transmitters. When a transmitter receives a command (e.g., Robot 3 forward left!), Doraemon stores the last command sent to the robot and observes the motion of the robots. Should the motion of the robot agree with the command, the probability of the identity is slightly increased (a factor of 1.1). On the other hand, there are many reasons why a robot does not follow the command: malfunction, an unknown obstacle in the path, noise in video processing, the robot is being pushed by another robot, occlusion, etc. In this case, Doraemon slowly decreases the probability of the identity assignment by a factor of 0.9.

6 Conclusion

This year, the development focused on extending the video server so that it does not require any coloured markers, manual tagging, or bar codes to determine the orienatation and the identity of our and our opponents robots. The Little Black Devils are the first team that correlates movement commands with the observed behavior of robots to identify them.

Although we had some problems, the approach proved possible and we believe the remaining issues in the robot identification can be solved before next year.