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Simple Soccer Robots with High-Speed Vision System Based on Color Detection Hardware

Linked99

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Abstract. *RoboCup team of "Linked99" employs very simple robot, with the high-speed and actual control based on the information of global vision camera. The global camera image is digitized by the special hardware according to the color information, and captured by PC to extract the coordinates of ball and all markers. These coordinate information is send to the other PC to determine the strategy of actions of robots, which will be implemented based on the techniques and knowledgements in RoboCup Simulation League.*

1 Overview of System

Figure 1 describes the overview of our team's system. The concept of our team is to employ simple, inexpensive robots and to control them by high-speed and actual vision feedback. The special hardware for color detection is developed and employed for our vision system to exract coordinates of ball and markers. Global strategy for the team is realized by rule based logic on the host computer.

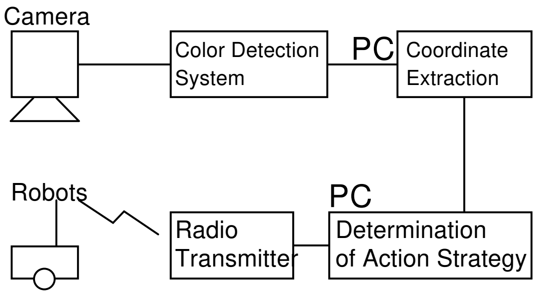

Figure 1: Overview of "Linked99" system

2 Vision System

The vision system is composed of two parts; real-time color detection system implemented by special hardware, and coordinate extraction implemented by the software processing of PC.

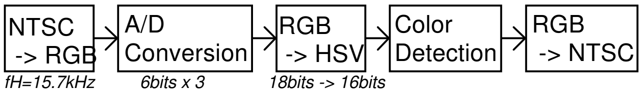

Figure 2: Structure of real-time color detection system

Figure 2 shows the structure of our real-time color detection system.

The video signal from global vision CCD camera is converted to RGB signal at first and then converted to digial signal of 6bits respectively. The pixel's signal pair of RGB signal is then converted the pair of HSV, Hue and Saturation and Value, which is more invariable to lighting condition than RGB which is implemented by look-up table of 4Mbits ROM. The color information of each pixel expressed in HSV is then judged the following four color detectors, which each detects that all of hue, saturation, and value are put in the preset ranges, and converted to gray NTSC signal according to the color detected, to be captured by gray scale frame grabber of PC, which is three times faster than full-color frame grabber. The details of these system will be presented in [1].

2.2 Coordinate extraction

The gray-scale image based on color detection generated by previous color detection system is captured by gray-scale frame grabber, PX610 by PC, and then they are labeled for each color independently, and then the coordinates of ball and each marker are calculated as their center of gravity. It is easy to process these sequences in video frame rate, since it is not needed to process for color information. The CPU, OS and programming language of the PC are PentiumII/450MHz, Windows95, and VisualC++4.0, respectively.

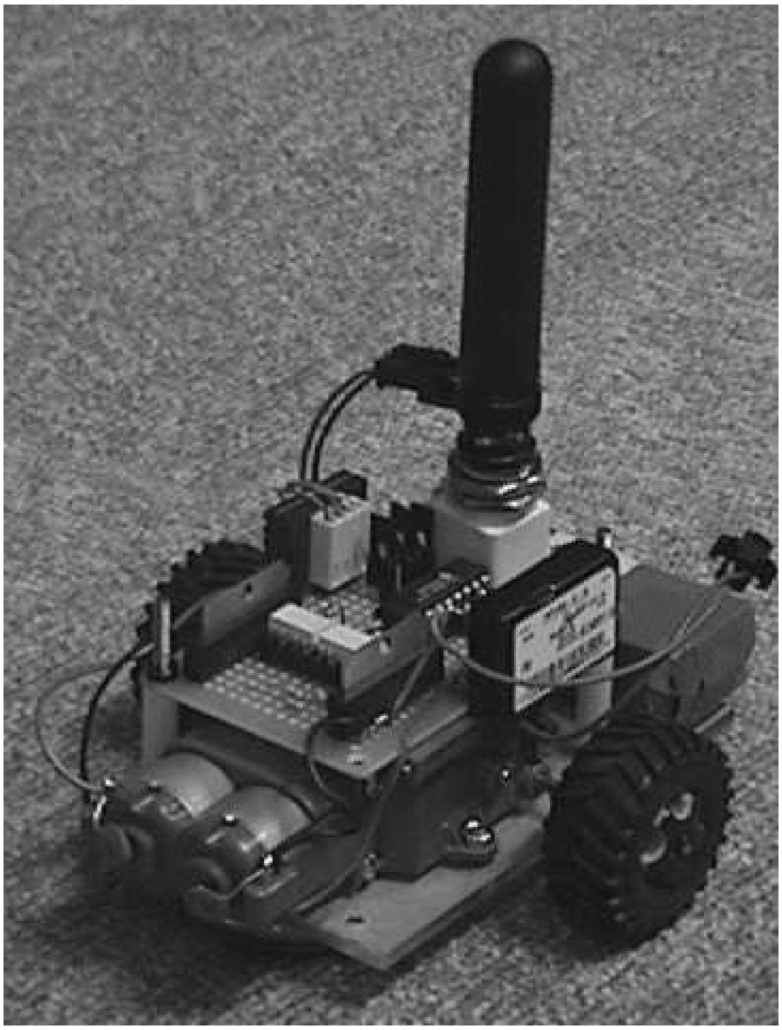

Figure 3: Photograph of "Linked99" robot: player

These coordinate informations are sended to the other PC to determine the robots' action strategy through Ethernet.

3 Structure of Robot

We have developed very simple, inexpensive robot, by assuming the high-speed and actual control based on the information of global vision camera. The goalie robot is also developed which can detect the ball by ultra-sonic sensors.

3.1 Robot controller

Figure 4(a) shows the photograph of developed player robot. The robot is controlled by PIC16F84 microcontroller. The action commands received through radio transmission are analyzed and the Mabuchi DC motors, according to left right wheel, respectively, are controlled according to the

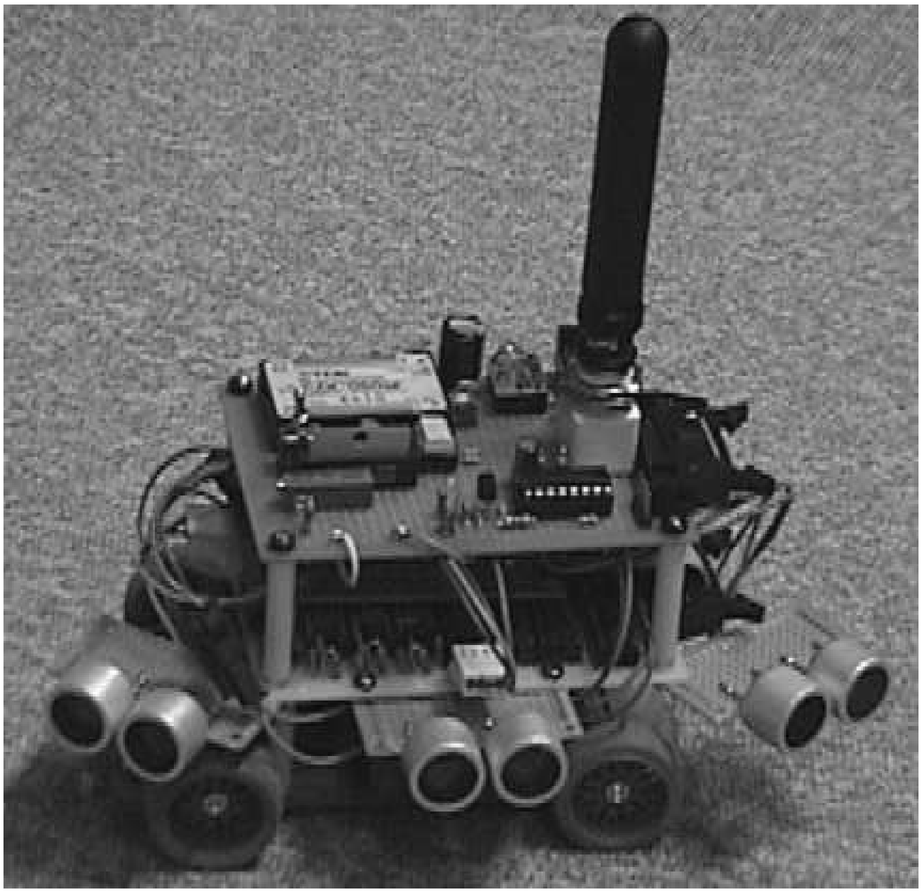

Figure 4: Photograph of “Linked99” robot: goalie

action commands. The motors are controlled to operate at the constant velocity in order to the robot should go straightly.

3.2 Action commands

There are four action commands for each robot, 'Go Forward', 'Go Back' (about 3cm, respectively), 'Turn Left' and 'Turn Right' (about 5 degrees, respectively), and each command is expressed in 1byte character. The action caused by each command is small, since the control from the vision information should be fast enough. The transmission rate of radio communiation is 4800bits per second.

3.3 Goalie robot

Figure 4(b) shows the photograph of developed goalie robot. The goalie robot has special structure; three ultra-sonic sensors to detect coming ball, one DC motor and four wheels to move horizontally, and wall detection sensor to recognize its position aroud the goal.

4 Strategy of Control

The coordinate information are sent to the other PC through Ethernet, and the strategy of control is determined there.

4.1 Interconnections with vision system

The coordinates of ball and each yellow and blue maker generated by vision processing PC through Ethernet are analyzed to determine the pair of yellow or blue maker and the another color maker employed to determine the direction of robot. After pairing the two markers for each robot, the position and direction are caluculated. These information are passed to the strategy determination program with the coordinates of ball and enermys' robots.

4.2 Strategy for game

Linked99 Team uses a high speed image processor that is constructed to RoboCup Small sized league and uses simple mechanism robots that have inexpensive moters rather than expensive stepping moters. Though they have very rough precision on positioning, Linked99 Team can control robots smoothly with vision.

Control model of this system is a Hierarchical Behavior Controller with rule-based decision making processor. This hierarchy consists of three layer; local controller, behavior rules, strategy-base. The lowest control level: local control is mounted on robots. This sub system can accept and execute six radio-commands such as 'go forward', 'turn right'. This process may execute by local processor (PIC) on each robot.

To estimate the efficiency of RoboCup special image processor, strategy is constructed in a simple style. Global strategy for the team is realized by rule based logic on the host computer. Robots role is as follows.

1. goalie: 1 robot, have reactive motion control on its local processor, to make a ball clear just in front of his goal.
2. defense: 1 robot, just help the goalie. The goalie can not kick a ball from area near the goal to the middle of the pitch, thus the defense robot should kick it. This robot have ability to play role as forward play. It, however, places side form like as the goalie to assist him, and will get a position between goal and ball.
3. forward: 3 robots, make the game in middle of field through the opponent goal. They are in triangle position each other. These robots have each roles; ie. right wing, left wing, center top. Both side robots pass the ball simply to the point middle of between center top robot and the opponent's goal.

5 Conclusion

We employ very simple robot, with the high-speed and actual control based on the information of global vision camera. The special hardware for color detection is employed in order to high-speed and actual vision system. Though the strategy of control is still under development, it will be implemented based on the techniques and knowledgements in RoboCup Simulation League.

Acknowledgements

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References

[1] J.Akita, "Real-time Color Detection System using Custom LSI for High-Speed Machine Vision," *RoboCup Workshop in IJCAI99*, 1999. (to be presented)