Robot Soccer System of SOTY 5 for Middle League MiroSot

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Abstract: Developing a multi-agent system amounts to searching for a method to implement an intelligent system composed of multiple cooperative agents with independent motion control. Multi-agent systems are more flexible and fault tolerant as several simple robot agents are easier to handle and cheaper to build compared to a single powerful robot for different tasks. Middle League MiroSot is a suitable testbed for multi-agent system research. The soccer game is different from other multi-agent systems, in that the robots in one team have to cooperate in the face of competition from the opponent team. The multi-agent control algorithm must comprise of low level kinematics and dynamics, and high level strategies to avoid obstacles and to compete with the opponent robots. In such a dynamic environment, a robot needs fast processing algorithms and a suitable robot structure. This paper presents the development of an SOTY 5 team robot for the Middle League MiroSot game. The effectiveness of the new robot soccer team will be demonstrated at the 2002 FIRA Cup.

Keywords: robot soccer, mobile robot, multi-agent, path following, vision system

1. Introduction

Developing a multi-agent system amounts to searching for a method to implement an intelligent system composed of multiple cooperative agents with independent motion control. Multi-agent systems are more flexible and fault tolerant as several simple robot agents are easier to handle and cheaper to build compared to a single powerful robot for different tasks. MiroSot is a suitable testbed for multi-agent system research. The soccer game is different from other multi-agent systems, in that the robots in one team have to cooperate in the face of competition from the opponent team. The multi-agent control algorithm must comprise of low level kinematics and dynamics, and high level strategies to avoid obstacles and to compete with the opponent robots. In such a dynamic environment, a robot needs fast processing algorithms and a suitable robot structure [1], [2], [3], [4].

Middle League MiroSot (MLM) uses a black (non-reflective) wooden rectangular playground which is $220cm \times 180cm$ in size with $5cm$ high and has $2.5cm$ thick white side-walls. The goal post is $40cm$ wide. A match shall be played by two teams, each consisting of five robots. One of the robots can be the goalie. The size of each robot is limited to $7.5cm \times 7.5cm \times 7.5cm$ [5]. Figure 1 shows the playground for MLM.

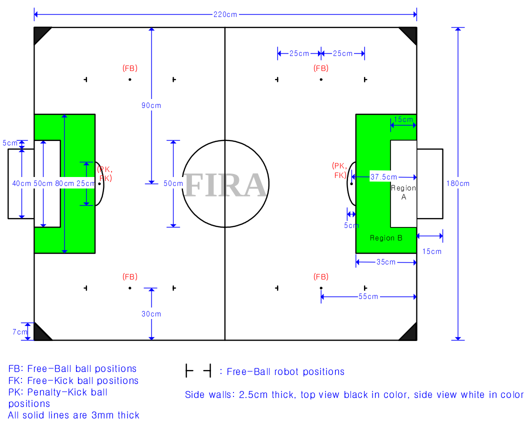


Fig. 1. Playground for Middle League MiroSot

This paper presents the development of a SOTY 5 soccer team robot. The body of the robot, a low-level controller, some strategies, and a vision system have been implemented and integrated. This development has resolved some problems experienced in our previous competition in the Middle League MiroSot category at FIRA Cup China 2001. The Middle League MiroSot game involves multiple robots that need to collaborate in an adversarial environment to achieve specific objectives. In that competition, our team was awarded 2nd place. The effectiveness of the new robot soccer team will be demonstrated at the 2002 FIRA Cup.

This paper is organized as follows. In Section 2, the robot soccer system of SOTY 5 is described. In Section 3, the low level control of the soccer robot is presented. Section 4 and Section 5 describe the strategy and the vision system for MLM, respectively. Concluding remarks follow in Section 6.

2. Robot Soccer System of SOTY 5

The developed robot is $7.5 \times 7.5 \times 6cm^3$ in size, and the weight is about $0.45Kg$. It uses two DC-motors which has 21.2 stall torque, 8,200 no load speed. Maximum speed of the robot is 1.5m/s. Figure 2 shows the newly designed body of the soccer robot.

ATMEL ATmega128 is used for CPU that has 16MHz clock and can generate PWM signals. L298N is the motor driving chip. In particular, we assign the role of counting encoder signals to ALTERA EPM6064S chip. Figure 3 shows the developed PCB board.

There is an overhead CCD camera that monitors the robots wearing a color uniform. The location of the overhead camera should be at a height of 2m or higher from the playground. The vision system consists of a CCD camera, Matrox meteor II frame grabber and Millennium I VGA card.

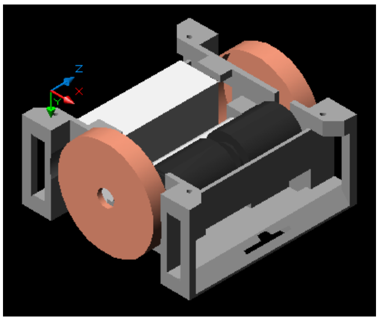


Fig. 2. Body of the soccer robot

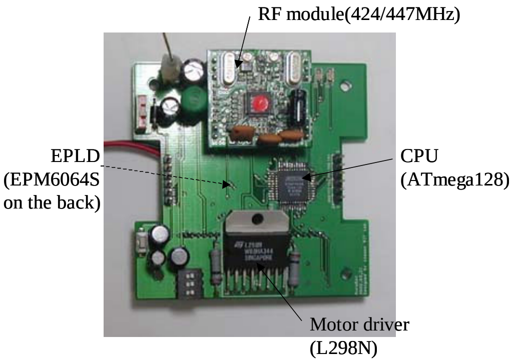


Fig. 3. Developed PCB board

This system can monitor the positions and the angles of five robots at 60Hz. ARFM 424HHz or 447MHz RF module are used, alternatively. A host computer and a robot have communication connections between them via the RF module using each serial port. Maximum speed of serial port is 19,200bps.

3. Low level Control

The low level control can be implemented by path generation and path following. The path can be generated by using a segment of line and an arc. The minimal radius of the arc should be checked by some tests with the robot. The path following controller can be implemented with the uni-vector field navigation method [4].

After generating the path, some violations such as two robots in our goal area, two robots in opposite goal area, target point towards the outside of the playground, or overlapped path causing a collision should be checked. To avoid violations, the concept of constraint lines and circles are considered. The constraint lines and circles can guide the robots not to come inside our goal area, not to come inside opposite goal area, not to collide with walls, and not to crash into other robots. Figure 4 shows the constraint lines and circles as dashed lines.

The algorithm of path generation is as follows: (a) Make all constraint lines of the playground in the initial routine. (b) Make a constraint circle for the ball. (c) Make constraint circles of our robots. (d) Make constraint circles of opposite robots. (e) Generate paths in priority order. (f) Modify the paths using constraint lines and circles of (a) to (d). (g) Find the cross points between the path and the constraints, and

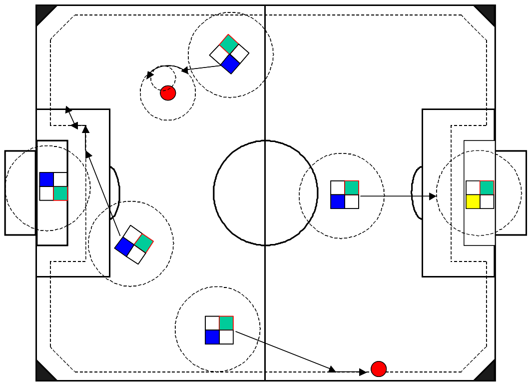


Fig. 4. Constraint lines and circles to avoid violations

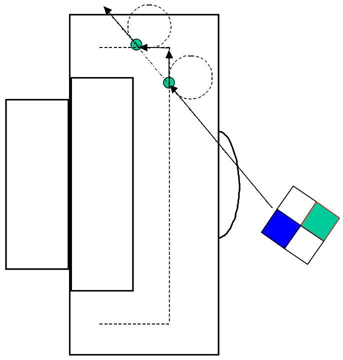


Fig. 5. Example of path generation using constraint lines and circles

add arcs at the cross points. The path generation method may be powerful, but needs accurate estimations of robot positions, robot heading angles, and ball position. Figure 5 shows an example of path generation. By this path generation method, the robot will not come into our goal area if the goalie robot is inside the goal area.

4. Strategy

4.1. Strategy Structure

In the SOTY 5 system, the robot roles have been divided by four types, such as attacker, defender, waiter, and goalie. Attacker is a robot which dribbles and shoots a ball. Defender is a robot which waits for the chance to be an attacker beside the current attacker. Waiter is a robot which waits for coming a ball in another area. Goalie is a robot

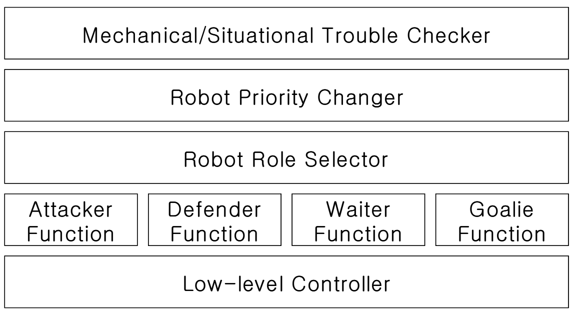
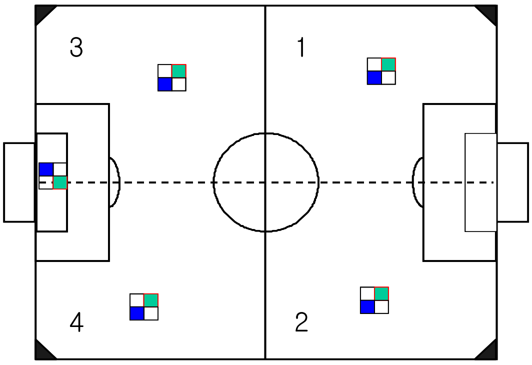
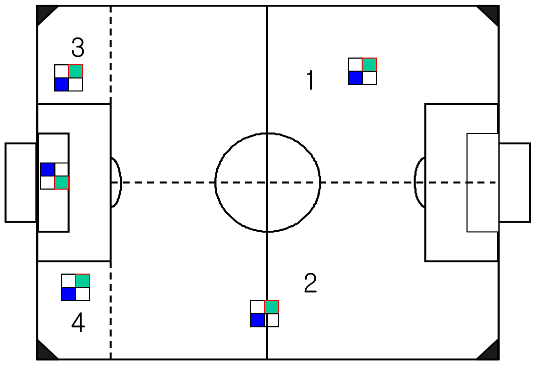


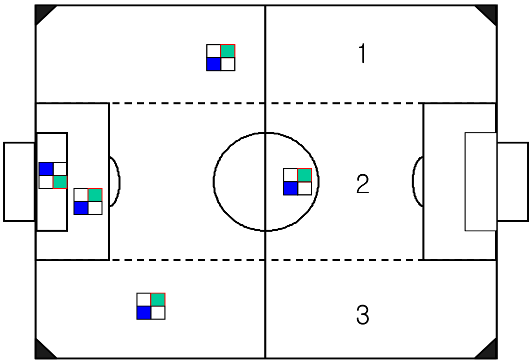
Fig. 6. Strategy structure of SOTY 5



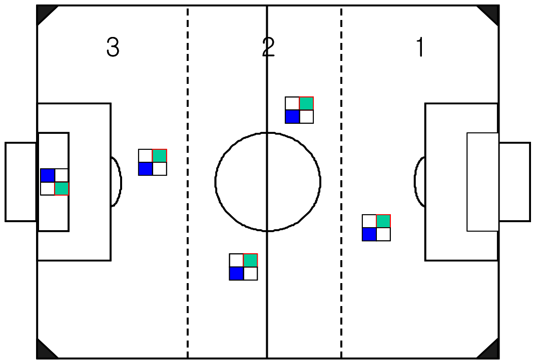
(a) Simple formation



(b) Strongly defensive formation



(c) Strongly offensive formation



(d) Layered-defensive formation

Fig. 7. Basic formations for Middle League MiroSot

which keeps our goal. Attacker, defender, waiter, and goalie have been implemented as each function module in program code. Figure 6 shows the strategy structure of SOTY 5. Robot role selector gives one role among attacker, defender, waiter, and goalie to each robot. At this selection, current positions, previous priority orders, current ball position, mechanical/situational troubles, and current formation can be considered. Robot Priority Changer changes the priority of each robot to give useful information at the next role selection. Mechanical/Situational Trouble Checker finds the robots with some troubles such as ambiguous position, moving trouble for attacker, seceding trouble from goal area for goalie, etc. The robot with troubles should have a low priority, and the low priority is considered at the next robot role selection.

4.2. Formation

Figure 7 shows four basic formations for Middle League MiroSot: (a) simple formation, which can balance between offense and defense. But robots can collide with other robot in each boundary, frequently. (b) strongly defensive formation, which has an advantage that it is possible to use easily the 3-a-side strategy. (c) strongly offensive formation, which enables three robots to attack together. (d) layered-defensive formation, which has an advantage of the fast changing between an offense mode and a defense mode. In the SOTY 5 system, the hybrid formation of layered-defensive formation for attacking mode and strongly defensive formation for defending mode has been used. The boundaries of areas 1, 2, 3 can be changed dynamically, and the area in which the ball is located has always two robots for attacking mode.

The strategies could be verified by using a simulator developed as shown in Figure 8.

5. Vision system

During robot soccer games, the regular illumination condition is indispensable but actually it is not guaranteed. Consequently it is not only difficult to configure colors for detecting objects such as a ball and soccer robots but also the vision program often miss positions of objects during the game. In this paper we propose the new color setting method which is robust by the area-partition in spite of the irregular illumination. The vision system has general characteristics similar to other teams'. In particular, we should follow two steps to set colors for the object detection. Firstly, area-partition points are freely pointed by several clicks of a mouse. Secondly, after grouping partitioned areas with similar illumination conditions by double-click of a mouse, colors are configured. That is, color configurations of grouped partition-areas are all the same. As this structure was adopted, the color setting was easier and the setting time was reduced. Since inner areas of the field are brighter and corner areas are darker than other areas in most cases, the operator can select better group of partitioned areas for color setting as shown in Figure 9. As a programmer adds the process to find and pass the color configuration of the partitioned area, at which objects were located previously, before the partial image labeling, general vision programs can adopt this color

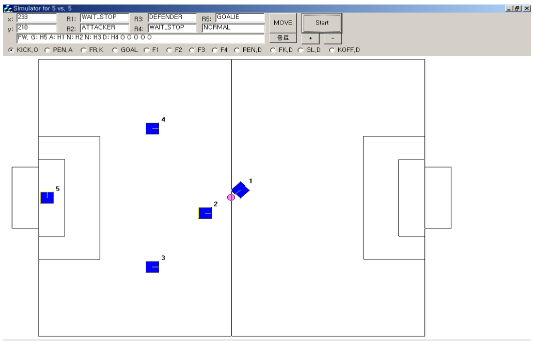
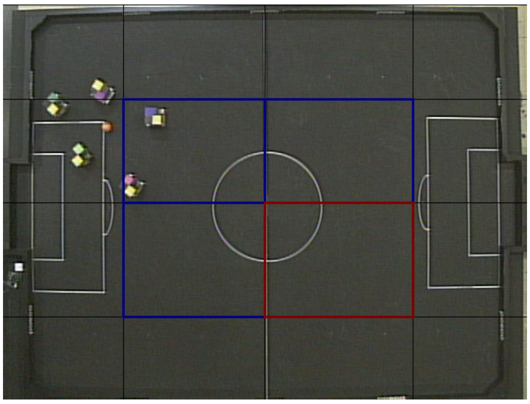
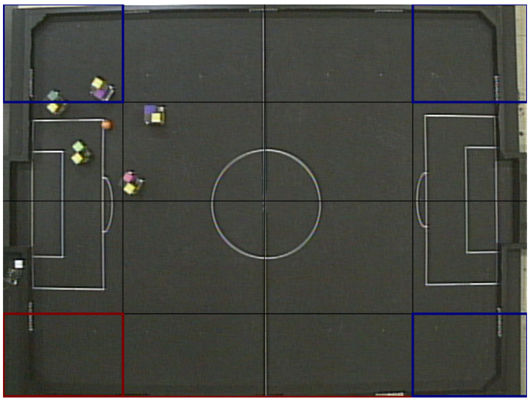


Fig. 8. Simulator for verifying strategies



(a) Color setting on bright areas



(b) Color setting on dark areas

Fig. 9. Color settings

setting method. This method could detect objects robustly despite any irregular illumination condition.

6. Conclusions

This paper has presented the development of an SOTY 5 team robot for the Middle League MiroSot game. The game strategies of the new robot soccer team have been verified by using a simulator developed. The effectiveness of the new robot soccer team will be demonstrated at the 2002 FIRA Cup.

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