Design and Implementation of a Soccer Robot with Modularized Control Circuits

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Abstract. RoboCup is designed to evaluate various theories, algorithms, and architectures for new challenges of Artificial Intelligent (AI) research. New challenges will import new functions into a soccer robot. Thus, a soccer robot with modularized control circuits is proposed to conveniently add new functions for further challenges. At present, the designed soccer robot, based on circuit function, has five modules: processor module, radio communication module, input/output module, supersonic module and extensible module. Five modules are together connected via Industry Architecture Standard bus (ISA bus) in extensible module. In addition, the motion planning of a soccer robot for kicking the ball is formularized to shoot goal. Experiment is also included.

1 Introduction

RoboCup is proposed as a standard problem to evaluate various theories, algorithms, and architectures for Artificial Intelligent (AI) research [1]-[2]. Its beginning is the ending of the Deep Blue, a computer chess team, beating Kasparov, human grand master chess. The Deep Blue team's win implies that computer chess lost its objective, the challenges of AI research. As a result, RoboCup replaces computer chess as AI challenges.

RoboCup has currently chosen soccer as its standard task. In RoboCup2001, there are five leagues, Small size, middle size, simulation, four-leg robot (AIBO) and RoboCup Rescue. The RoboCup Rescue league is first beginning in this year. In addition, many exhibition topics, such as humanoid robot, RoboCup Junior and Industrial robot, have progressed for the ultimate goal of RoboCup: a team of autonomous humanoid robots plays with the human World Cup champion team under the official regulation of FIFA. From low-level control to high-level planning, RoboCup offers an integrated research, including mechanical, electronic, and information engineering, and covering broad topics such as non-holonomic control system, motion planning, robot localization, visual servoing control, multi-agent systems, etc. Not only in the present soccer but also for the ultimate goal, RoboCup faces many unknown challenges. New challenges will compel soccer robots to have new functions. Soccer robots always need to add

A. Birk, S. Coradeschi, and S. Tadokoro (Eds.): RoboCup 2001, LNAI 2377, pp. 459–464, 2002.

or replace a function in itself. Therefore, this research is devoted to proposing a soccer robot with modularized control circuits.

Modularizing control circuits will be convenient to adjusting its function for the RoboCup competition. The modularizing is based on control circuits' functions for adding or replacing easy. The control circuits of the designed soccer robot are divided into five modules, including processor module, radio communication module, input/output module, supersonic module and extensible module. Five modules are connected by Industrial Standard Architecture (ISA) bus, which is a general bus used in IBM PC. The ISA bus will make the soccer robot extend its functions using PC's hardware. In addition, for demonstration, experiments show the designed soccer robot can be controlled to kick the ball toward the opponent goal.

The rest of this paper is organized as follows. The next section introduces how to modularize the control circuits of a soccer robot. Section 3 describes the formularizing of the motion planning of a soccer robot for kicking the ball toward the opponent goal. Experimental results are presented in section 4. Section 5 gives some conclusion and discussion.

2 A Soccer Robot with Modularized Control Circuit

It is necessary to adjust functions of a soccer robot for facing a new challenge considered in RoboCup. Easily adding or replacing a function stimulates this research to Modularize control circuits in a soccer robot. However, how to modularize control circuits has many considerations, such as circuit connections or circuit functions. The circuit connection consideration results in less connection line between the different modules, but the circuit function consideration has the advantage of easily combining together every module. Easy combination is the objective of modularizing control circuits of a soccer robot. Thus, modularizing is based on the circuit functions of the designed soccer robot.

Fig. 1 is the control circuits' block of the designed soccer robot. Based on its functions, the control circuits are divided into five modules: processor module, radio communication module, input/output module, supersonic module and extensible module. The processor module contains one microprocessor 80196, two ROMs for saving program code, and one flash RAM for reserving information after the soccer robot is powered off. The radio communication module is based one single chip processor 8951. It is used to implement radio protocol, to treat ultrasonic sensors, and then to communicate with microprocessor 80196 via one programming parallel port controller 8255. The input/output module contains one LCD module, used as the output for showing soccer robot's situations, and one 4*4 keyboard, used as the input for sending commands to the soccer robot. In addition, this module also includes one timer/counter controller to receive the encoder signal from two DC motors and then to record the move position of the soccer robot. Fig. 2 is the photograph of the soccer robot, which includes five modules.

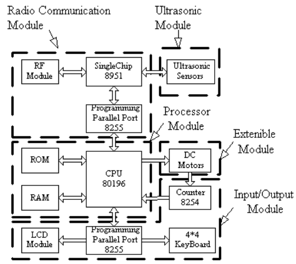

Fig. 1. The control circuit of the designed soccer robot.

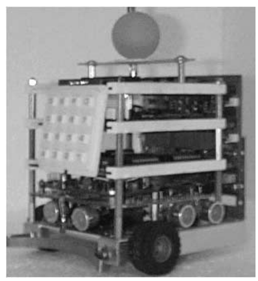

Fig. 2. The photograph of the designed soccer robot.

3 Motion Planning of a Soccer Robot

The motion planning is based on Dubins' [3] and Reeds&Shepp's [4] cars to develop the algorithm, which is applicable to the robots for soccer play. Dubins' car is the optimal path under only considering forward move, but Reeds&Sheep's car is the consideration under both forward and backward move. Here, the motion planning of a soccer robot does not intend to find the optimal path, i. e. the short path, because of the following two reasons:
1). Finding the optimal path will exhaust computer time and then result in insufficient time for the other tasks in the soccer robot system, such as image processing and play strategy planning. 2). During competition, the environment of the soccer play is dynamic, and has many obstacles.
For the crowded and dynamic environment, the optimal path may be always varying, and the soccer robot system then sinks into solving this path. The main consideration of the soccer robot's motion planning is the strategy whether is fit for RoboCup competition.

The competition strategy is defined to first rotate the soccer robots at appropriate orientation before they want to execute their tasks. This competition strategy has the advantage of quickly changing the soccer robots' tasks to deal with opponent behaviors and then to avoid losing score or to have win. Thus, assume that the soccer robot's motion satisfies A1 as follows. A1: Before starting to move, a soccer robot has been at appropriate orientation. In addition, a soccer robot usually needs the fastest speed to move toward its goal position. This idea also stimulates us to propose assumption A_2 for the motion planning of a soccer robot in the following. A_2: The soccer robot moves at a constant speed. Note that as a soccer robot to move on a curve, the constant speed will result in it at a constant curvature. Besides, the move speed is usually the maximal speed.

Under the ideas of Dubins and Reeds&Sheep, the optimal path is composed of straight lines and curves at constant curvature. It is well know that the velocity commands of path on a straight line are

$$\begin{aligned} u_\ell &= V \\ u_\gamma &= V \end{aligned} \tag{1}$$

where u_ℓ and u_γ are the velocity command of left and right wheels, respectively, and V is the velocity of the robot following the straight line. For a curve at a constant curvature, the velocity commands are

$$\begin{aligned} u_\ell &= V + WV/R \\ u_\gamma &= V - WV/R \end{aligned} \tag{2}$$

where R is the rotational radius. The motion planning of the soccer robot is based on the path formed by straight lines and curves. Fig. 3 shows the idea of path planning for finding the straight line L_1 and the curve C_1 at the curvature R. The motion planning will solve u_ℓ and u_γ from Eqs (1) and (2).

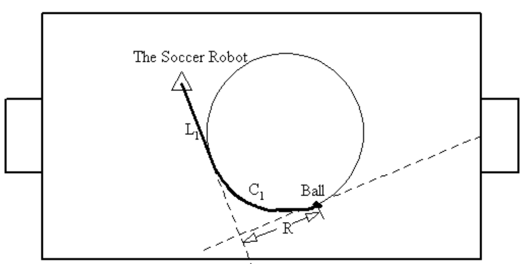

Fig. 3. The motion planning of the soccer robot.

4 Experiment of the Motion Planning

Assume that the center of the play field is the coordinate position (0.0, 0.0). As the soccer robot starts at (0.0, -0.6), Fig. 4 shows the soccer robot is controlled to follow the planned path and then to kick the ball forward toward the opponent goal. Fig. 5 shows the left and right motors' velocity, including desired and actual velocity. The time between two velocity commands is 30ms. In Fig. 4, the car and ball positions are shown one time after passing eight commands.

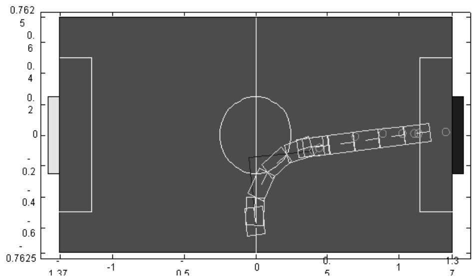

Fig. 4. As starting at (0.0, -0.6), the soccer robot is controlled to kick the ball forward toward the opponent goal.

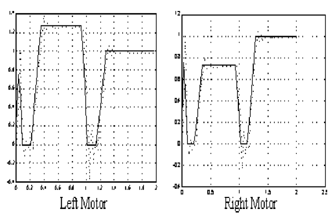

Fig. 5. The motor velocity as the soccer robot starts at (0.0, -0.6) (Solid line: desired velocity; Dotted line: actually velocity).

5 Conclusion

In this paper, modularizing control circuits is proposed to build a soccer robot. The control circuits of the soccer robot are divided into five modules based on their functions. Five modules are connected via ISA bus, a standard bus of IBM PC. This feature will make the soccer robot easy use IBM PC hardware and then helpfully extend it to develop commercial products. In addition, the motion planning of the soccer robot first divides its passing path into the segments of straight lines and curves. And u_ℓ and u_γ at every segment are then solved by eqs (1) and (2). The solved u_ℓ and u_γ are used to control the soccer robot to pass the desired path. Experiment shows the proposed motion planning is useful for soccer robots.

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