SP-Vanquish 2001 Robocup F2000 Soccer System

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Abstract. This paper describes the Medium-Sized Robocup project undertaken by the Singapore Polytechnic in preparation for the Robocup 2001 competition in Seattle, U.S.A. Having taken part in two earlier competitions, it was decided that a new system be built to take advantage of the advances made by other teams over the years.

1 Introduction

A robot soccer system involves multi-agent collaborative behaviour on a real-time platform. Real time constraints include the ability to identify quickly whether an object perceived by the robot's perception system is another robot, a wall or a ball. The intelligence required to make prompt decisions to actuate the motion control scheme of the robot is another time critical element in this dynamic environment where the ball, and other robots are constantly moving. The ability to meet these real-time constraints while striving to achieve the objective of putting the ball into the opponent's goal is crucial to a successful game. Each mobile robot is independent. Each has its own autonomous behaviour. Yet they must act in concert in order to accomplish a common task effectively.

The Robocup Medium-Sized category is played on a carpeted surface of size 9m by 5m. Each team is made up of 4 robots including a goalkeeper. The maximum length and width a rectangular robot is specified at 500 mm. Its maximum height is 800 mm. The soccer ball used is a FIFA standard size-5 winter (orange) ball.

2 System Overview

The SP-Vanquish soccer system consists of four autonomous robots, each carrying its own on-board perception, cognition and execution systems.

The perception system is made up of a self-contained omni-directional vision system and several infrared transceivers. These serve to form a model of the playing environment around each robot.

The cognition system is built around a Pentium III single board computer complete with a digital I/O board and a wireless LAN. A secondary source of computing power is obtained through the wireless link to a command PC.

The perception-cognition system will then make the appropriate decisions on the required action of the robot. These actions include getting the robot to approach, intercept or block the ball, dribble the ball to the opponents goal area, take on a defensive posture and execute obstacle avoidance of the opponent's robots or the perimeter wall. Where appropriate, a pneumatic driven ball kicking mechanism will be actuated.

3 System Architecture

The overall system architecture of the SP-Vanquish robot soccer system is structured in a way that allows individual robots to be independent in terms of their ability to perceive the environment and to act on it to play a game of soccer. Yet it is collaborative during game play because the individual players come together to act as a team.

The system architecture used to achieve this is a distributed one. Each robot is equipped with enough computing power to make local decisions. However, they are all linked together by a wireless local area network that is controlled by a Master. The Master will make higher-level co-ordinating decisions. Figure 1 shows how this is accomplished.

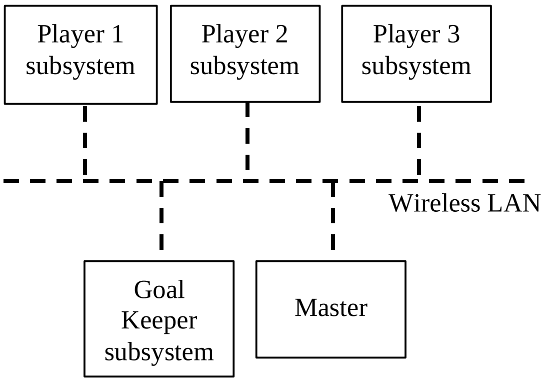

Figure 1: Overall System Architecture

4 Robot Player Subsystem

4.1 Mechanical Structure

The robot mechanical structure is custom-made and has been redesigned (from previous competitions) to accommodate both the Single Board Computer and the Omni-directional vision system. A pneumatic driven kicking mechanism has also been added to each robot. Two high efficiency motors drive the robots and they manoeuvre around the field using the wheel-chair principle.

The goalkeeper is also custom-made and has a slightly different design from the other players. This is so that it can better perform its role to guard its goal.

4.2 The Perception System

The main component of the perception system is an on-board omni-directional vision system. This consists of an RGB camera, a conical mirror and a vision card. The vision system is tuned to recognise the 5 colours representing the 2 goalposts, the 2 team colours and the ball on the field. When these colours come within the camera's field of vision, the size of each colour patch together with its x and y co-ordinates are output to the cognition engine. The cognition engine will then act on this information to actuate the motors. Because the visual input is highly distorted, customised software is necessary to correctly interpret the image obtained.

Several IR transceivers are present to detect for immediate obstacles such as the presence of other players and the wall. These transceivers are mounted in a manner that allows them to tell a player from a wall. Different strategies are then used to overcome the obstacles.

4.3 The Cognition System

The cognition system is made up of 2 hierarchical modules linked together by a radio frequency link.

The first and more basic cognition module is found on-board each player and goalkeeper. This is known as the player subsystem. It is implemented using a Pentium III single board computer and a digital I/O card. The purpose of this module is to collect information from the player's perception system and map out a course of action that is both purposeful and useful based on these inputs. It then controls the player's or goalkeeper's motors to execute the action mapped out. Examples of actions mapped out by this module include approaching to ball, stop movement, turning movement, defensive action and attacking action.

Where appropriate, the pneumatic ball kicking mechanism will also be actuated.

The second cognition module is a personal computer. The personal computer acts as a supervisory controller that can co-ordinate the actions of the players in the course of a game. During game play, the supervisory cognition system will continually receive updates from all players on the field about the ball position and their relative distance to each goal area. It will then map out a high level strategy that will dictate which player to defend and which to attack.

In dead ball situations, this module can also command each player to move in a specific manner, e.g. in a straight line, turn around etc. It can also get each player to take a penalty kick, free kick or execute the movements required in a technical challenge.

The link between the two cognition modules is a wireless LAN. The LAN is a standard 2.4GHz IEEE 802.11 compliant product from Compaq.

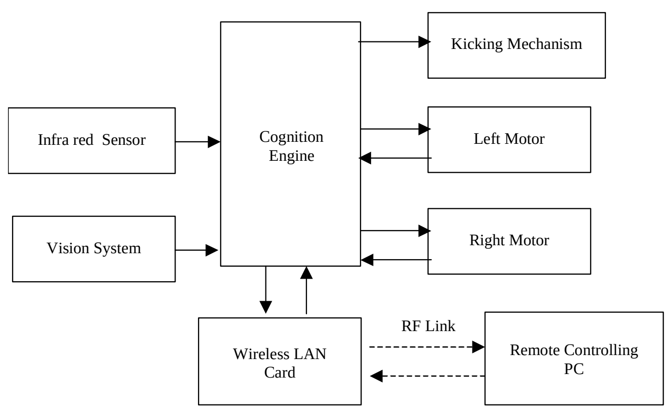

Figure 2 Block diagram of the Player Subsystem

The operating system on each SBC is Windows 98. The software in the player subsystem is written in Visual C++ programming language. If the vision system in each player is unable to detect the ball, the player will be made to move within in a limited area to look for the ball. If it detects the ball, the co-ordinates and distance of the ball from the robot, and the relative positions of both goalposts will be sent to the supervisory computer. The player will not approach the ball unless it gets permission to do so from the supervisor.

Once permission is granted, the robot will approach the ball. According to the instruction given by the supervisory computer, the robot will then proceed to either to try to score a goal or to defend its own goal.

The supervisory computer's software is written in the C programming language. The software receives information from each player about its position relative to the ball and its orientation. It then computes using this information and decides the robot that is in the best position to approach the ball. It then gives permission to that robot to move towards the ball.

4.4 The Execution System

The execution system consists of a pair of motor driven wheels that will move the robot in a manner that allows it to accomplish its goals. Each motor is driven by a L298 single chip motor controller. The speed of the motor is controlled by Pulse-width modulated (PWM) signals supplied by the digital I/O board. An encoder emitting 200 pulses per revolution was used to close the control loop of each motor.

A pneumatic driven kicker running at 8 bar of air pressure is also built. This is made up of 2 pneumatic pistons connected in parallel to a cross bar. When activated, it is able to drive the ball forward simulating a kicking action. 0.75 litre air reservoirs are used to contain the compressed air.

5 Conclusions

In this paper, a broad description of the design and implementation of the SP Vanquish robot soccer system 2001 is given. With the inclusion of several improvements over our previous model, it is hoped that our team can be more competitive in the forthcoming competition.

References

1. Kitano,H. RoboCup : The Robot World Cup Initiative, *Proc. of The First International Conference on Autonomous Agent (Agents-97)),* Marina del Ray, The ACM Press, 1997.
2. Ma ZM, et al Real-time Control of Soccer-playing robots and Its Team Work Strategies, Internation Conference on Neural Networks & Brain , 1998. (Accepted).
3. Arkin, R. C., Motor Schema-based Mobile Robot Navigation, International Journal of Robotics Research, 92-112, 1987
4. Asada et al, Purposive Behavior Acquisition for a Real Robot by Vision-based Reinforcement Learning, Machine Learning, 23: 279-303, 1996
5. Peter Stone, Manuela Veloso, and Sorin Achim, Collaboration and Learning in Robotic Soccer, Proceeding of the Micro-Robot World Cup Soccer Tournament, Taejon, Korea, 1996
6. Hiroaki Kitano, The Robocup Synthetic Agent Challenge 97, Proceeding of the Fifteenth Inter. Joint Conf. On AI, San Francisco, CA, 1997.