5dpo-2000 Team description - v2000

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Abstract - This paper describes the 5dpo-2000 team. The paper will be divided into three main sections, corresponding to three main blocks: the Global Level, the Local Level and the Interface. These Levels, their subsystems and some implementation details will be described next.

1 Introduction

This is our second participation in the Robocup Competition in the F-2000 League.

The design and construction of a F-2000 team is naturally a on going process. We found that the first and most important issue to be dealt with is the sensorial problem. Without knowing their position and the ball position, the robots are not able to deploy any kind of coherent action. So we are trying to tackle the problem of extracting this information from multiple cameras and other sensors. As the information is acquired by each robot, in terms of a sensor fusion problem, we have distributed system. The data must be fused, taking in account their reliability and the communication influence: limited bandwidth, variable delays and possible interferences.

Each robot has a video acquisition system and a radio link to communicate with the other robots and with the coach. If this system works well enough, we could rely exclusively on it. As a extra precaution we are using an electronic compass to have a independent measure of the robot heading.

As the radio link cannot be completely reliable we tried to fit the robots with some autonomy so that they can survive a considerable starvation of orders from the Coach. That can ease the problem of lost or bad packets.

The whole team can be seen as a system divided in two basic levels.

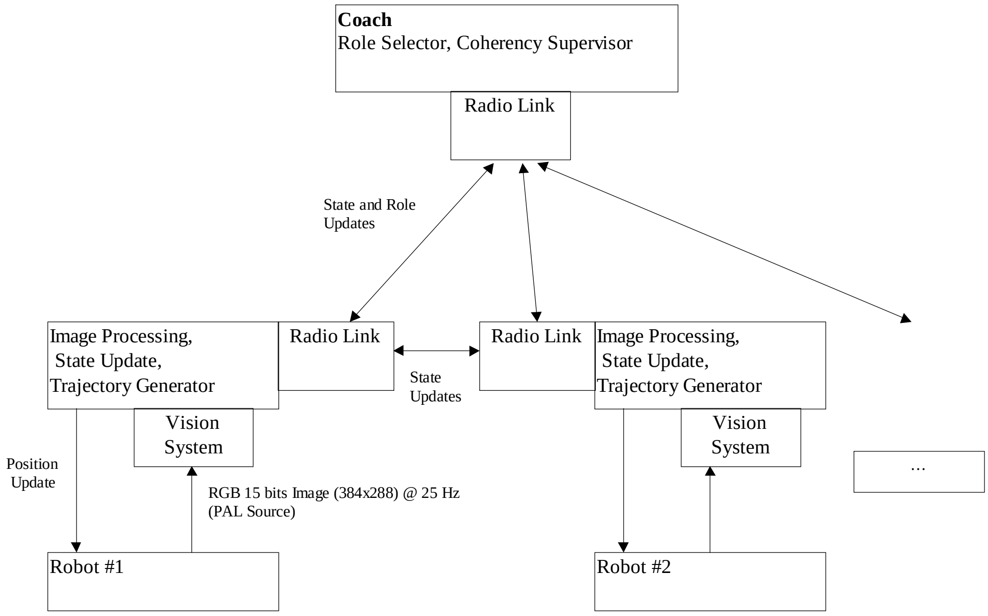

Fig. 1. Robots and Coach and the information flowing between them.

We will now describe the team and its subsystems.

2 The Robots

First we describe the basic mechanical and electrical design of the robots.

The robots are fitted with two differential wheels. The wheels are driven independently by separated stepper motors. Two extra free wheels ensure the static stability. The use of stepper motors frees us from the necessity of using any kind of gear reduction and encoders.

The robots are presently powered by embedded Lead-Acid batteries. The motors are driven by two H-bridges that are directly powered from the batteries. The on board controller is a 8-bit RISC microcontroller (Atmel AVR90S8515). A on board PC deals with the higher level functions.

Each embedded PC uses a radio LAN, at 2.4 GHz. Its maximum throughput is 2 Mbits.

The PC code was done in C++ in DOS but in a 32 bits environment. That was the only way to ensure the hard real-time nature of the tasks. Other operating systems could not guarantee hard real-time behavior.

Our team uses a local vision system as a primary sensorial source for each robot. This is our positioning system for the robots, for the opponent robots and for the ball.

This system consists in one color video cameras, placed on a rotating tower over the robot. The TV signal from these cameras is feed to a video acquisition board placed in the local PC. This board is capable of placing a digitalization of each image frame in the PC memory without CPU intervention, thus wasting almost no processor time. In the end of this process the board can signal the processor the conclusion of that task.

As we are using PAL cameras the image frequency is 50 Hz with alternating even and odd frames. We are only using even frames therefore we have an image update frequency of 25 Hz. Based on the acquired image we try to identify the ball position and also the robots' position and orientation.

An electronic compass gives the robot a independent heading measure.

We consider a robot an autonomous unit at least for a short time frame. The robots are capable of generating a queue of tasks to be performed. These tasks may include following a specified trajectory, holding the ball, passing it along to another team member or maybe shooting for goal. The local control system tries to enforce those orders in the predefined sequence.

Some team tactics are maintained at all times like some defense mechanisms that are enforced during the match. In any case, the defense robots stand in alignment in such a way that the robot that holds the ball can't easily shoot for goal. This implies the presence of a path planner present in each robot.

3 The Coach (Global Level)

This is the global control level. A standard PC hosts this system and all the algorithms are implemented in C++. Another task is performed in this system and that task is the data and decision visualization. That is very important because it provides a real-time assessment of the system quality .

The global state of the system is updated based on the information flowing from the robots. Data fusion is attempted and adversary robot moves are tracked. By observing the present system state as well as a global mid-term strategy, new roles are assigned and sent to the players.

This level closes the global loop but there is some intrinsic lag that degrades its optimal performance. Each robot acquires the image, then some time is lost processing it and more time is lost to transmit the data to the coach. There, the reasoning unit must decide the new course of action and it is necessary to wait for the next time slot to send information to the robots. That is why we still implemented a local loop, running in each robot, that can show a much better performance in some tasks than the globally closed loop.

Another role of the coach is to maintain a "official" global state that can be used to ensure the coherency of the global system state viewed by each robot.

4 The Communications - The Radio Link

The radio link allows sending and receiving short packets that carry messages from the Coach to the robots and between robots. It is based on the radio LAN Present in each robot an on the coach.

The information flowing is used by all the robots to update their view of the global state. That is performed by a local Kalman filter. In that way we can have each robot gaining extra information from the other robots' sensors.

5 Conclusions

In this paper we described the 5dpo-2000 team and the solutions we found to this problem. Recognizing the overall system state (the ball position and speed, our team's robots' state and the adversarial robots' state) using vision in distributed environment is still a very difficult task. And the quality of the team behavior is very dependent from the accuracy of that system.

Another major challenge is, even with accurate knowledge of the system status, the decision of what to do. The range of options, some discrete and some continuous has many dimensions and cannot be easily searched. A lot of heuristic rules must be used to trim the possibilities and the best framework to represent and find them is a matter that requires still a lot of research.

Bibliography

1. Arthur Gelb, Joseph Kasper Jr.,Raymond Nash Jr., Charles Price, Arthur Sutherland Jr.: Applied Optimal Estimation, The M.I.T. Press, (1989)
2. J. Borenstein, H. R. Everett, L. Feng, S. W. Lee and R. H. Byrne: Where am I? Sensors and Methods for Mobile Robot Positioning, (1996)
3. J. Carvalho: Dynamic Systems and Automatic Control, Prentice-Hall, (1993)
4. Huibert Kwakernaak, Raphael Sivan: Linear Optimal Control Systems, Willey-Interscience, (1972)
5. Jean-Claude Latombe: Robot Motion Planning, Kluwer Academic Publishers, (1991)
6. Paulo Costa, António Moreira, Armando Sousa, Paulo Marques, Pedro Costa, Aníbal Matos, "5dpo-2000 Team Description", Robocup 1999 - Robot World Cup Soccer Games and Conference, Stockolm, Sweeden, pp 217-220, 1999.