5dpo Team description - v2000

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Abstract - This paper describes the 5dpo team as it is being prepared for the competitions to be held in 2000. The main systems, vision, decision and control, and some implementation details will be described next.

1 Introduction

This is our third participation in the Robocup Competition. This design is a evolutionary step over the previous one. Our robots comply with the F-180 League Regulations that constrain their dimensions: the occupied floor area must not exceed 180 square centimeters and the height must be bellow 15 centimeters. That limits the processing power and the kind of sensory devices that can be fitted in. On the plus side it also limits the costs and eases the mechanical design.

The main options that shape the way the 5dpo team was designed were: the use of a global vision system with more than one camera, the relative autonomy (in a short time frame) expected from the robots and the unidirectional nature of the radio link.

The whole team can be seen as a system divided in two basic levels: the global and the local

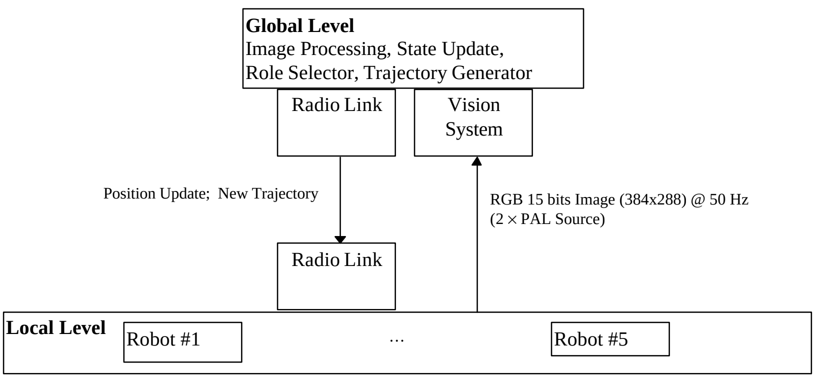

Fig. 1. The key subsystems and the information flow.

The global vision system saves us from building robots with onboard cameras and the corresponding processing power. It also gives us a global view which is independent from the robots' state. Also, the computing power and RAM available at the global Level is some orders of magnitude above the one present in each robot (a 550 MHz P3 with 128 Mbytes of RAM versus an eight bit microcontroller with 256 byte of RAM @ 8MHz)

2 The Global Level

The global state of the system is updated based on the vision. A fuzzy system classifies the color of each pixel and aggregates them in contiguous groups. The observed groups are matched and that information is incorporated in the state resorting to a set of Kalman filters tuned to the dynamics of each kind of object. Another fuzzy rule based engine is used to classify opponents intents. By observing the present system state as well as a global mid-term strategy, short term orders are generated and sent to the players.

Through this system we can close the global loop. It must be stressed that while the "sampling" frequency of this loop is 50 Hz, there is some intrinsic lag that degrades its optimal performance. The PAL signal takes 20 ms to deliver each frame, then some time is lost processing it, the decision subsystem must decide the new course of action and it is necessary to wait for the next time slot to send some orders to the robots. That is why a local loop can show a much better performance in some tasks than a globally closed loop. As our robots do not have any kind of local sensors, we can not close any local loop.

Short term orders try to account for typical adversary moves. They are anticipated using a model for their behavior. Naturally, the quality of this model has a direct link with the quality of the tactic behavior achieved by the team.

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 predictor not only for the robots but also for the ball and the opponents.

All these systems are implemented in C++ in DOS but in a 32 bits environment. We used the free compiler DJGPP. That was the chosen way to ensure the hard real-time nature of the tasks. Other operating systems could not guarantee hard real-time behavior or there were no drivers available for some of our hardware.

3 The Interface between Levels

3.1 The Radio Interface

The radio link allows sending and receiving short packets that carry messages from the PC to the robots. We have the radio channel time slotted synchronously with the global Control Loop. Currently we use the radio link only in a one-way mode: from the PC to the robots. That limitation exists only in the firmware of the robots and we can upgrade this software if the necessity arises.

3.2 The Video Interface

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

This system consists in two PAL color video cameras, placed directly above the playing field. The TV signal from these cameras is feed to video acquisition boards placed in a PC. This boards are capable of placing a digitalization of each image frame in the PC memory without CPU intervention, thus wasting almost no processor time. We process each line as it arrives but almost a frame can be buffered if some other task is being executed.

Based on the acquired image we must identify the ball position and also the robots' position and orientation. As the robots are fitted with colored Ping-Pong balls, the second problem is similar to the first one. It is easier because the background is stable and, in the case of our team's robots, chosen by us. Better, there is not any kind of occultation for these balls. The playing ball can be partially or totally hidden by the robot's body. It can have the green or the white of the lines as background. That makes its tracking more difficult. There is another problem: typically, the ball's speed can be grater than the robots speed. We are using a high speed shutter to minimize motion blur.

Another problem is distinguishing each of our robots. That is being achieved by reading a bar code placed on the top of each robot. The bar code uses four squares which give us 16 possible numbers, for the five robots we choose only the combinations that have two black and two white squares and that can not be confused when we miss only one square.

4 The Local Level

The robots are fitted with two differential wheels. The wheels are driven independently by separated stepper motors. There is no third wheel and the robot is sustained by a pair of pods. A castor would result in a more complex mechanical design as well as an increased uncertainty in its dynamical model.

The robots are presently powered by embedded Ni-Cd 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). All digital circuitry gets its power from a low dropout linear regulator, for the radio, and a switched regulator for the rest of the circuitry.

Two small single frequency RF modules (433 MHz and 418MHz) are used to communicate with the external global controller. Only one can be used at a time but they can be software selected. We broadcast small packets to maximize the reliability of this channel. In each packet we specify the target speed for each wheel and if it is to power the kicking device.

One of the major improvements for this year is the presence of a kicking device in some of our robots. That can increase the attacking options and gives us a new set of possibilities. Now, it is feasible to have passes between robots and the decision system is being expanded to deal with it.

5 Conclusions

In this paper we described the 5dpo team state as of 2000 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 is still a very difficult task specially under not ideal conditions. And the quality of the team behavior is very dependent from the accuracy of that system.

The decision of what to do, even with accurate knowledge of the system status, it is a major task on its own. 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.

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