5dpo-2000 Team Description for Year 2003

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Abstract. This paper briefly describes the design principles of the hardware and software of 5dpo-2000 team. Relevant control issues are also addressed, especially some details of the application of Kalman Filters in the design of the localization algorithms.

Hardware Architecture

Mechanically, the 5dpo-2000 robots have two geared DC motors that drive independent wheels. The only extra actuator is an electromagnetic kicking device. A single PAL camera on top of the robot is used. This camera is mounted on a pan system with a range of 360 degrees. NiMh batteries (24.4V/6000mAh) power the robots. A Switching Mode power supply is used to power the general consumer PC motherboard and the rest of the electronics. The power drive modules are home made, based on an Atmel AVR 90AT8515 microcontroller. This module is also used to probe all sensors and command actuators. Sensors are wheel odometry, 2 active IR distance sensors and the neck alignment signal. Actuators are kicker and neck stepper motor controls. The on board PCs have CPUs in the order of 733Mhz and vision acquisition is based on a BT878 chip PCI card. This configuration allows a very small latency in image acquisition.

Robots and Supervisor use wireless LAN cards that are IEEE 802.11b compatible.

Software Architecture

5dpo-2000 team is based two different software modules. For each robot there is the HAL (Hardware Abstraction Layer) and the DEC (DEcision and Cooperation) module. The HAL is responsible for controlling the robot and also for gathering information from its sensors and analyzing it in an appropriate way. It then sends filtered high-level information to the DEC module that is responsible for individual and cooperative decision-making. Communication between the DEC modules implements cooperation and coordination. The HAL and the DEC modules communicate via sockets and may or may no co-exist in the same machine. Currently the 5dpo team is migrating the both HAL and DEC software from Delphi/Windows to Kylix/Linux.

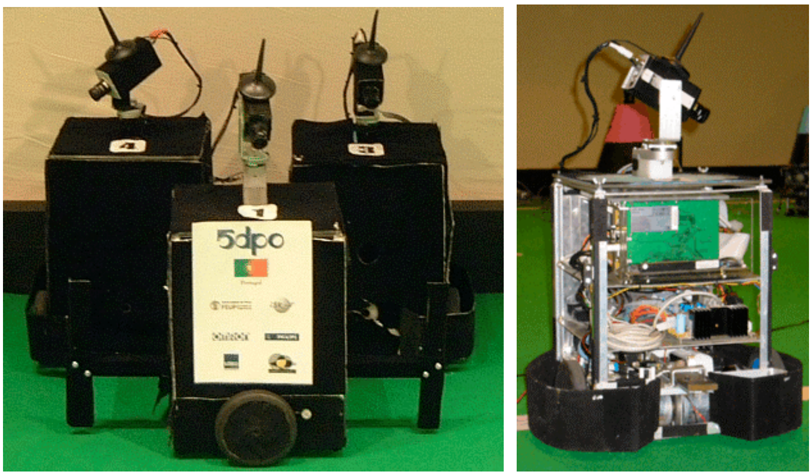

Fig. 1. On the left three robots of the 5dpo-2000 Team where robot number one is the goal keeper; on the right a robot without black “clothing”

The HAL performs the image acquisition and processing and gateways other sensor and control information. Image processing is based on a resolution of 384x288 and spatial sub sampling is used [Sousa02]. Image processing is done based on previous calibration of colors, forming color blobs and detecting edges. Object recognition is done in the DEC module because it involves real world knowledge.
The decision and control systems are based on hierarchical state machines. Each robot has a Role that may require a number of Tasks that, in turn, may require a mesh of different Actions. State transitions are based on the world state that is shared among robots and there are coordinated Role changes according with global team strategy [Reis01]. Robots can have full autonomy in case of communication failure.

Interesting Localization Issues

Our image analysis can extract the white field lines, the poles and the goals. The angle and distance to the robot of the features can be estimated with some accuracy for nearby objects. As the distance increases, the accuracy of the angle estimation remain high but the distance measurement error climbs quickly. That information is used on our Extended Kalman Filter that joins these measures with the odometry to estimate the robot position. Due to our camera field of view, most of the time there is only one pole visible at a time. As the camera scans its surroundings it is very likely that the seen pole changes from time to time.

Figure 2 shows simulation runs of the stated problem where the covariance of the system is shown around the estimated position represented by arrows that show the direction of the robot.

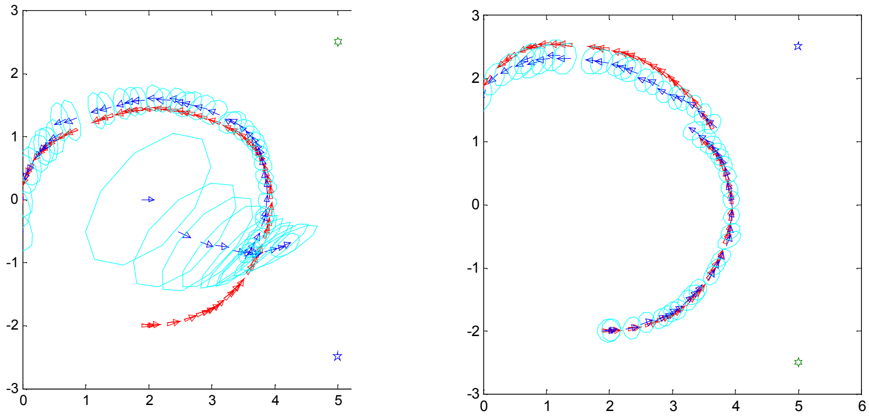

Fig. 2. Simulation Runs: Left Figure (L) – Robot Estimated position converging to real position; Right Figure (R)– Robot crashes and changes real position and estimates also converges to real robot's position

6 Conclusions

We presented the design principles for the mechanics, hardware and software of 5dpo-2000 team. The EKF implemented in the robots achieves successfully data fusion between odometry and field markers as estimates converge even in the presence of serious discrepancies. The characterization of the covariance of the measurements is important to ensure that the state and covariance estimates remain meaningful. The presented formulation is already implemented in the robots of the 5dpo-2000 team.

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