Team Sweden

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1 Introduction

"Team Sweden" is the Swedish national team that entered the Sony legged robot league at the RoboCup '99 and RoboCup 2000 competitions. We had two main requirements in mind when preparing our entries:

1. The entry should effectively address the specific challenges present in this domain; in particular, it should be able to tolerate errors and imprecision in perception and execution; and
2. it should illustrate our research in autonomous robotics, by incorporating general techniques that can be reused in different robots and environments.

While the first requirement could have been met by writing some *ad hoc* competition software, the second one led us to develop principled solutions that drew upon our current research in robotics, and that pushed it further ahead.

2 Team Development

The work was distributed over three universities in Sweden, in the cities of Örebro, Ronneby, and Stockholm. These cities are separated by a geographical distance of up to 600 Km, which made the project organization especially demanding. In return our team work, started with RoboCup '99, created a successful cooperation framework, which went beyond the RoboCup experience.

Team Leader: Alessandro Saffiotti (`asaffio@aass.oru.se`)
Team Members: include the authors of this paper, plus eight undergraduate students: M. Karlström and K. LeBlanc from Örebro University; M. Broberg, I. Bergmann, J. Johansson, P. Johnsson, R. Krejstrup, B.M. Lindberg, and B. Smeds from Blekinge Institute of Technology.
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The Team in Melbourne was represented by six members: J. Johansson, P. Johnsson, K. LeBlanc, B.M. Lindberg, A. Saffiotti, and Z. Wasik.
Web page: `http://www.aass.oru.se/Living/RoboCup/`.

P. Stone, T. Balch, and G. Kraetzschmar (Eds.): RoboCup 2000, LNAI 2019, pp. 643-646, 2001.

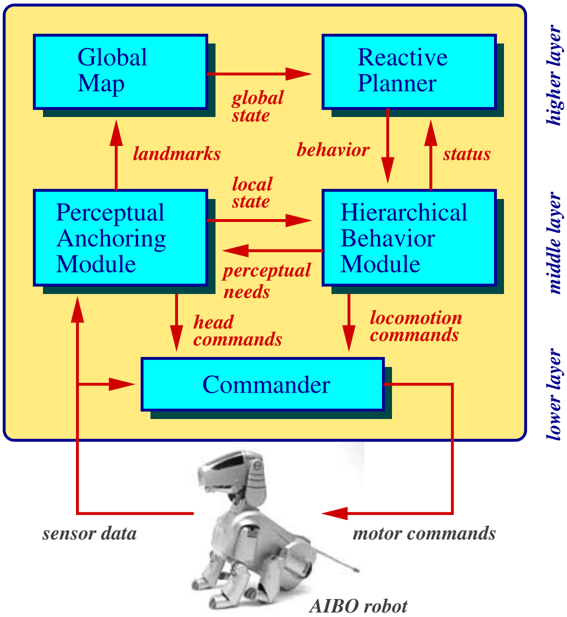

Fig. 1. The variant of the Thinking Cap architecture used by Team Sweden.

3 Architecture

Each robot is endowed with a layered architecture, inspired by the Thinking Cap architecture,[1] sketched in Fig. 1. The lower layer provides an abstract interface to the sensori-motoric functionalities of the robot. The middle layer maintains a consistent representation of the space around the robot (PAM), and implements a set of robust tactical behaviors (HBM). The higher layer maintains a global map of the field (GM) and makes real-time strategic decisions (RP).

4 Vision

The locus of perception is the PAM, which acts as a short term memory of the location of the objects around the robot. The position of each object is updated by a combination of three mechanisms: by *perceptual anchoring*, whenever the object is detected by vision; by *global information*, for the static objects only, whenever the robot re-localizes; and by *odometry*, whenever the robot moves.

The PAM also takes care of selective gaze control, by moving the camera according to the most urgent perceptual needs. Current perceptual needs are communicated to the PAM by the HBM in the form of a degree of importance attached to each object in the environment. The PAM uses these degrees to guarantee that all currently needed objects are perceptually anchored as often as possible. (See [4] for details.)

[1] The autonomous robot architecture based on fuzzy logic in use at Örebro University: see `http://www.aass.oru.se/~asaffio/Software/TC/`.

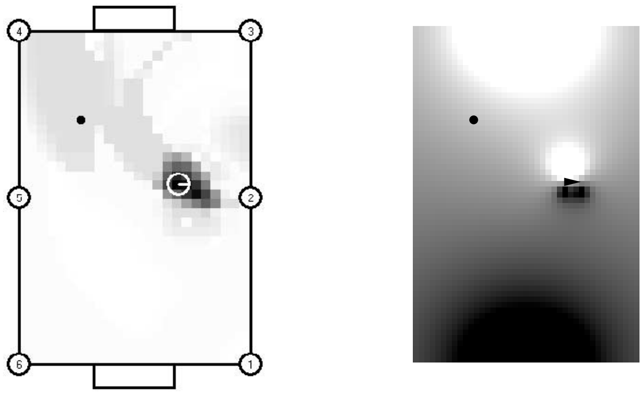

Fig. 2. Left: fuzzy position grid, including a black circle representing the ball location. Right: the corresponding electric field (white is positive).

Object recognition relies on the color detection hardware in the Sony robot, to which we provide the intended color signatures (produced off-line from samples). We use a model-based approach to combine color blobs into features, and use domain knowledge to filter them. For instance, a green blob over a pink one are fused into a landmark; this is rejected, however, if it is too low over the field.

5 Localization

Self-localization in the Sony legged robot league is a challenging task since: egomotion information is extremely inaccurate due to leg slippage and collisions; landmarks can only be observed sporadically, since the camera is needed for tracking the other objects; and visual recognition is subject to unpredictable errors (e.g., mislabeling). To meet these challenges, we have developed a new self-localization technique based on fuzzy logic, reported in [1]. The main advantages of this technique are: (i) it only needs qualitative motion and sensor models; (ii) it can accommodate sporadic observations; (iii) it can recover from arbitrarily large errors; and (iv) it involves low computational costs.

This technique, implemented in the GM module, relies on the integration of approximate position information, derived from observations of landmarks and nets, into a fuzzy position grid — see Fig. 2 left. To include egomotion information, we dilate the grid by a fuzzy mathematical morphology operator. Using this technique, our robots could maintain a position estimate within $\pm 10\,cm$ and $\pm 5°$ from the true position in average game situations. Localization was done continuously during normal action; stopping the robot to re-localize was only needed occasionally, e.g., in case of major errors due to an undetected collision.

6 Behaviors

The HBM implements a set of navigation and ball control behaviors realized using fuzzy logic techniques and organized in a hierarchical way [3]. As an illustration, the following set of fuzzy rules implement the "GoToPosition" behavior.

```
IF (AND(NOT(PositionHere), PositionLeft))   TURN (LEFT);
IF (AND(NOT(PositionHere), PositionRight))  TURN (RIGHT);
IF (OR(PositionHere, PositionAhead))        TURN (AHEAD);
IF (AND(NOT(PositionHere), PositionAhead))  GO (FAST);
IF (OR(PositionHere, NOT(PositionAhead)))   GO (STAY);
```

More complex behaviors are written using fuzzy meta-rules that activate concurrent sub-behaviors. We used this hierarchical composition strategy to write some significantly complex behaviors, like the "GoalKeeper" one.

Game strategies for the players are dynamically generated by the RP. This implements an action selection scheme based on the artificial electric field approach (EFA) [2]. We attach sets of positive and negative electric charges to the nets and to each robot, and we estimate the heuristic value of a given field situation by measuring the electric potential at the ball position — see Fig. 2 right. This heuristic value is used to select the behavior that would result in the best situation: in our example, performing a "GoBehindBall" would maximize the potential at the ball position.

The EFA can account for motion, manipulation, and information gathering actions in the same framework. Moreover, different strategies can be encoded and tested very easily. For instance, in order to prepare the robots for the three technical challenges, we only had to modify a few charges.

7 Action/Walking

The Commander module implements head movements and kicking actions. It also accepts locomotion commands from the HBM in terms of linear and rotational velocities, and translates them to an appropriate walking style. We relied on the walking styles provided by OpenR. These turned out to be less effective than most of the specialized walking routines implemented by other teams.

8 Conclusion

The general principles and techniques developed in our research could be successfully applied to the RoboCup domain. Fuzzy logic proved beneficial for writing robust behaviors, developing an effective gaze control strategy, and providing reliable self-localization. The electric field approach was a convenient way to encode high level strategies. Our main weakness was the ineffective walking style.

References

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