Team Sweden 2003

K. LeBlanc[1], S. Johansson[2], J. Malec[3], H. Martínez[4], and A. Saffiotti[1]

[1] Center for Applied Autonomous Sensor Systems
Örebro University, S-70182 Örebro, Sweden

[2] Department of Software Eng. and Computer Science
Blekinge Institute of Technology, S-37225 Ronneby, Sweden

[3] Department of Computing Science
Lund University, S-22100 Lund, Sweden

[4] Department of Information and Communication Engineering
University of Murcia, E-30100 Murcia, Spain

Abstract. "Team Sweden" is a multi-university team competing in the Sony legged robot league of RoboCup since 1999. This paper shortly describes the preparation of the Team Sweden entry for RoboCup 2003. The main innovations with respect to the previous year are: (i) higher-stance walking style, (ii) cooperative ball perception, and (iii) dynamic role assignment.

1 Introduction

"Team Sweden" is a cooperative effort which involves universities in Sweden and abroad. In 2003, the sites of activities are: Örebro University (coordinator), Lund University, the Blekinge Institute of Technology, and the University of Murcia in Spain. Since the birdth of Team Sweden in 1999, this distributed nature has made the project organization demanding but has resulted in a rewarding scientific and human cooperation experience. The Team identity this year is as follows:

Team Leader: Kevin LeBlanc (`kevin.leblanc@aass.oru.se`)
Team Members: From Örebro: J.P. Cánovas, A. Dahllöf, and A. Saffiotti; From Lund: M. Green, P. Mörck, J. Malec, and S. Nowaczyk; From Blekinge: N. Forsman, S. Johansson, and T. Samuelsson; From Murcia: F. Bas, D. Herrero, and H. Martínez.
Team home page: (includes on-line publications)
`http://www.aass.oru.se/Agora/RoboCup/`.

We had two main requirements in mind when we started to work on RoboCup:

1. Our entry should effectively address the challenges of uncertainty in this domain, where perception and execution are affected by errors and imprecision;
2. it should illustrate our research in autonomous robotics, by incorporating general techniques that can be reused in different robots and environments.

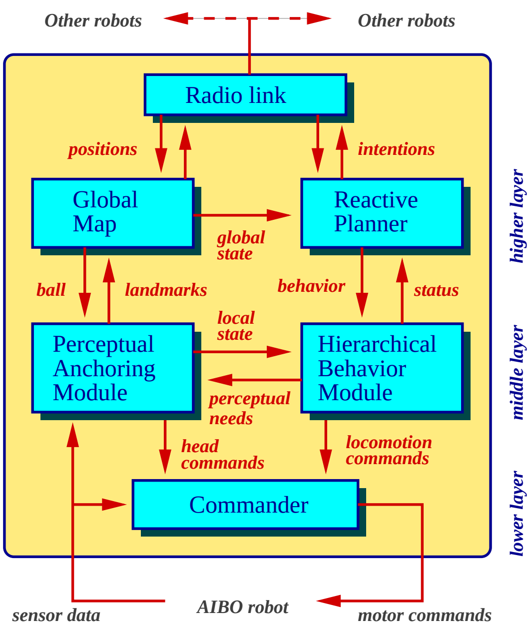

Fig. 1. The variant of the Thinking Cap architecture used by Team Sweden.

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 Architecture

Each robot uses the layered architecture sketched in Fig. 1. This is a variant of the Thinking Cap.[5] 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, Perceptual Anchoring Module), and implements a set of robust tactical behaviors (HBM, Hybrid Behavior Module). The higher layer maintains a global map of the field (GM, Global Map) and makes real-time strategic decisions (RP, Reactive Planner). Radio communication is used to exchange position and coordination information with other robots.

[5] The Thinking Cap is an framework for building autonomous robots jointly developed by Örebro University and the University of Murcia. See `http://www.aass.oru.se/~asaffio/Software/TC/`.

3 Motion control

The Commander module accepts locomotion commands from the HBM in terms of linear and rotational velocities, and translates them to an appropriate walking style. This simplifies the writing of motion behaviors, that are easily portable between different (legged and/or wheeled) platforms. The Commander module also controls the head motion, and implements several types of kicks.

Our walking styles are based on the code for parametric walk created by the University of New South Wales (UNSW)[3]. We have modified the UNSW walking style in order to inprove speed and to maintain a higher posture. The higher posture results in an improved estimate of the ball position since the camera can still track the ball even when this is very near to the body of the robot. Moreover, the front legs are less advanced with respect to the body, resulting in less risk to hit the ball by mistake when approaching it. Finally, the more stretched position of the legs reduce the risk of the legs of two robots getting entangled when the robots are side by side.

4 Perception

The locus of perception is the PAM, which acts as a short term memory of the location of the objects around the robot. At every moment, the PAM contains the best available estimate of the position of these objects. Estimates are updated by a combination of three mechanisms: by *perceptual anchoring*, whenever the object is detected by vision; by *odometry*, whenever the robot moves; and by *global information*, whenever the robot re-localizes. Global information can incorporate information received from other robots, e.g., about the ball position.

Object recognition in the PAM relies on three techniques: *color segmentation* based on a new fast region-growing algorithm that takes as seeds the output from hadware color detection [8]; *model-based region fusion* to combine color blobs into features; and *knowledge-based filters* to eliminate false positives. For instance, a green blob over a pink one are fused into a landmark; this may rejected, however, if it is too low over the field. Special-purpose vision algorithms have been implemented to solve the technical challenges.

The PAM also takes care of selective gaze control, by moving the camera according to the current perceptual needs, communicated by the HBM [6].

5 Self-Localization

Self-localization in the Sony legged robot league is a challenging task: odometric information is extremely inaccurate; landmarks can only be observed sporadically since a single camera is needed for many tasks; 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]. This technique only needs qualitative motion and sensor models, can accommodate sporadic observations during normal motion, can recover from arbitrarily

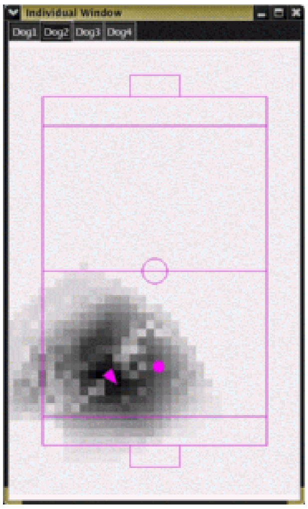

Fig. 2. The fuzzy self-localization grid.

large errors, and has a low computational cost. The result of self-localization is used to make strategic decisions inside the RP, and to exchange information between robots in field coordinates.

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. 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 $\pm 20\,cm$ and $\pm 10°$ 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 and behavior selection

The HBM implements a set of navigation and ball control behaviors realized using fuzzy logic techniques and organized in a hierarchical way [5, 7]. For instance, 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 obtain by composing simpler ones using fuzzy meta-rules that activate concurrent sub-behaviors. Behaviors also incorporates perceptual rules used to comunicate the current perceptual needs to the PAM.

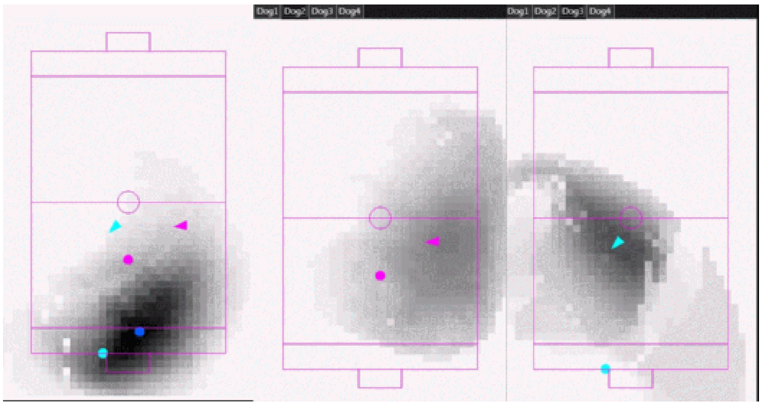

Fig. 3. Sharing of information. Combining two imprecise estimates into an accurate one.

Game strategies for the players are dynamically generated by the RP. This implements a behavior selection scheme based on the artificial electric field approach (EFA) [4]. 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 some *probe* position — for instance, the position of the ball. This heuristic value is used to select the behavior that would result in the best situation.

Each robot can assume one of three different roles: *attacker*, *defender* or *supporter* (waiting for a pass). Roles are implemented in the RP by modifying the charges, the probes and the set of applicable behaviors. Role selection is based on the current field situation and is done independently by each robot. Consistency of role selection is guaranteed by the fact that the robots share the same information about the objects in the field, as explained below.

7 Information sharing

We use radio communication to exchange information among the robot about the position of the objects in the field, especially the ball. Information from different robots is fused into the GM using an original approach based on fuzzy logic, reported in [2]. In our approach we see each robot as an expert which provides unreliable information about the location of objects. The information provided by different robots is combined using fuzzy logic techniques, in order to reach agreement between the robots. This contrasts with current techniques, which average the information provided by different robots, and can incur well-known problems when information is unreliable.

Fig. 3 shows an example of cooperative ball localization. The left window shows the ball grid resulting from the sharing of information. Darker cells have higher degrees of possibility. The two triangles represent the robot's estimates of their own positions. The three small circles near the bottom represent the point estimates of the ball position according to each robot (lighter circles) and as a result of the fusion (darker circle). The middle and right windows show the self-localization grids for robots 1 and 2, respectively. In this example, both robots happen to have a rather poor self-localization, as can be seen from the blurring of the two individual self-grids. Correspondingly, the individual estimates for the ball positions are relatively inaccurate, and quite different from each other. When intersecting the fuzzy sets, however, we obtain a fairly accurate fused estimate of the ball position (left window). Note that just averaging the estimates of the ball position produced by the two robots indipendently would result in an inaccurate estimate of the ball position.

8 Conclusion

The general principles and techniques developed in our research could be successfully applied to the RoboCup domain. In particular, fuzzy logic was beneficial in writing robust behaviors, providing reliable self-localization, and achieving cooperative perception. The electric field approach proved to be a flexible way to encode high level strategies for different player roles.

Acknowledgements

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