Dutch AIBO Team at RoboCup 2005

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Abstract. The Dutch AIBO Team is a multi-institute team which competes in the 4-legged robot league of RoboCup since 2004. Our team combines serious research with serious fun: collaborative autonomous (intelligent) systems are applied in Soccer, our shared application domain. This team description paper briefly outlines our current activities for RoboCup 2005.

1 Introduction

The Dutch AIBO Team has grown considerably since its first year. We started as a group of researchers and students from the universities of Amsterdam, Delft, Twente and Utrecht, and the DECIS Lab. Since then we have grown, including researchers and students from the universities of Groningen and Eindhoven, as well as Saxion University of professional education. Our unified efforts are intended to foster our individual and joined research interests in collaborative autonomous systems.

We are in the process of establishing a joint research plan with shared domains of application, including robot soccer. For this purpose, we aim for 2006 to establish a shared architecture which can be used for both research purposes and soccer competitions. A likely candidate is the Tekkotsu framework http://www.Tekkotsu.org (e.g., see [6]) which may offer us the flexibility and modularity to establish joint intra-team research activities. It is our intent to port our RoboCup 2005 code to the new framework for RoboCup 2006.

For RoboCup 2005 we have chosen to again use the German Team Code of 2004 [5] as the basis for our participation. This builds on our experiences from last year, when we used the 2003 German Team code [4]. A number of our improvements and additions to that code base are currently being transferred [3]. In addition, a research project on behavior-based vision for a goalie was undertaken in Fall 2004 and the project's results (see below) are also incorporated in our RoboCup 2005 code.

Of the nine groups currently involved in the Dutch AIBO Team, the groups of Technical University Delft (quantitative imaging and human machine interaction), University of Amsterdam, University of Utrecht and Saxion University of Professional Education explicitly contribute to our RoboCup 2005 participation. Both researchers and students of these groups play an important role in realizing our ambitions – their enthusiasm and creativity greatly add to the attractiveness of this research field. DECIS Lab provides organizational support for the robot soccer events in 2005.

We participated at the German Open earlier this year with a large group and had the opportunity to experiment with our code. Although we lost both games the first day and we did not immediately qualify for the quarter finals, we were able to improve the code, remove apparently untested portions, and stage a comeback on the second day, in which we qualified for the quarter finals and honorably lost 2-1 from the Darmstadt Dribbling Dackels (who are part of the German Team). The learning experience from German Open is invaluable for forging this year’s team and rationalizing our soccer-related research goals.

In the remainder of this document the involved soccer research groups briefly outline their intended contributions and extensions to the code base.

2 Technical University Delft

The Quantitative Imaging Group (formerly known as Pattern Recognition Group) studies a wide variety of methodologies and applications in the field of image processing and pattern recognition. Within the fields of industrial inspection and robot vision, we focus on the themes "vision based motion & motion based vision", "sensor data fusion", and "hardware architectures for real-time imaging". Within the AIBO project we have assigned one MSc student (~1 year) on the subject of high speed robust color vision. This project resulted in an accepted poster at the RoboCup 2005 conference on a behavior-based vision system [2].

In this approach, a fundamentally different view on the software architecture of vision-based soccer playing robots is proposed. In the classical view such an architecture is often based on independent *tasks* that constitute one big *sense-think-act loop*, e.g. sensing (vision), analysis (localization), synthesis (behavior) and acting (motion). In this paper the architecture is divided into a hierarchy of *behaviors*, where each behavior represents an independent sense-think-act loop. Based on this view we have implemented a behavior-based vision system on an AIBO, improving performance due to object-specific image processing, behavior-specific image processing and behavior-specific self localization.

The benefits of this approach is that in each behavior, only a limited set of vision algorithms is executed; only the ones that contribute most to the overall performance. Since other algorithms are not executed and thus require no CPU-time, there is significantly more effective processing power available for individual algorithms. When thinking in behaviors, persons new to programming a robot have to understand only a single behavior at the time, concerning only few image processing algorithms. The drawback (or advantage?) of this approach is that the behavior programmers will need some basic knowledge on all the associated fields: image processing, self localization, behavior control as well as motion control.

We have used our behavior-based vision system to realize a goalie that can localize more accurate and more reliable. Its design allowed him to stay in and guard his goal under a large variety of lighting and environment conditions.

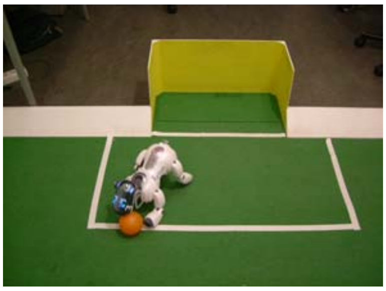
a) Goalie position, the goalie stands in his goal.	
b) Goalie clear ball, the goalie clears a ball from the penalty area	
c) Goalie return to goal, the goalie finds its way back to its goal	

Fig. 1. Basic goalie behaviors identified. For each behavior a different vision system is used.

For a goalie we have identified three behaviors (fig 1) with different vision solutions.

- Goalie position. The goalie stands in the centre of his goal when no ball is near. It moves its head around and thus is likely to see the field-lines of the penalty area very often and at least one of the two nearest flags once in a while.

- Goalie clear ball. When the ball comes into the penalty area, the goalie will clear it, return to the center of goal and return to the behavior *goalie-position*. While walking to the ball the head is aimed at the ball; when controlling the ball, the head is positioned over the ball. In these situations the quality of the sensor input tends to be low. The same image processing solution is used as for *goalie-position behavior*, detecting the lines and near flags, only the particles in the self locator are updated much slower. Flags and lines detected at far off angles or distances are totally ignored. The algorithm that detects whether the premises for “I am in the goal” is still valid, runs on a lower pace; so the robot longer works with the assumption that he is standing between ball and goal, without actually verifying that this is true.
- Goalie return to goal. When the goalie is not in his penalty area, he has to return to it. The goalie walks around while scanning the horizon with its head. When his own position is determined, the goalie tries to walk straight back to goal, facing his own goal. When the goalie returned in his goal, he returns (via the governing behavior) to the state *goalie- position*.

The system was tested under various lighting conditions, off-line using sets of images, and on-line in real tests for a playing goalie. The performance of the goalie easily doubles and it can play soccer under a much wider range of lighting and environment conditions. For more information including experimental results, see our RoboCup 2005 publication [2].

3 University of Amsterdam

The Intelligent Autonomous Systems group studies methodologies to create intelligent autonomous systems, which perceive their environment through sensors and use that information to generate intelligent, goal-directed behavior. This work includes formalization, generalization, and learning of goal-directed behavior in autonomous systems. The focus is on perception for autonomous systems, learning and neuro-computing, principles of autonomous systems and hardware and software systems.

In this year's Autonomous Systems course, 4 students worked full-time for 4 weeks on preparing the DAT2005 code (based on GT2004 [5]) for the necessary changes to comply with the new rules (i.e. the new field dimensions).

A team of two master students spent some time on developing new tools for RobotControl (the PC debugging interface to the AIBOs). In particular, a Deployment Tool was added that facilitates the memory stick creation. It is possible to store different binary packages for the AIBOs on the same computer in a single file as well as different color tables that can be uploaded to the AIBOs by FTP via the wireless network. These pre-composed binary packages can easily be exchanged between the participating universities of the Dutch AIBO Team for later testing.

Secondly, an independent and more precise auto-calibrating robot localization tool was developed that uses small (external) lights that are attached to the AIBOs and the field corners. With the tool it is possible to reliably measure the performance and precision of the beacon recognition (flags, goals, other players) and self localization.

In combination with the Deployment tool we can now derive exact specifications on the performance of different binaries and color tables which simplify the cooperation of the different universities and gives an exact measure on their performance.

Thirdly, this exact localization information can be used to position the AIBOs without the need of manual calibration to automatically collect images from the field from predefined positions. These are then analyzed by a new toolbar in RobotControl to compute offline semi-automatically more precise color tables.

A master student has been assigned for the Blindfolded AIBO Challenge. Therefore, a new common world model has been developed and implemented on the AIBOs, that allows the continuous exchange of landmark information (with landmarks here standing for whatever an AIBO can recognize as an object and assign an position to, like flags, goals, the ball and other AIBOs). This landmark information is enriched with validity and confidence factors, to enable the receiving AIBOs to fuse the new sensor data reliably with their own findings. The quality of the fusion of (remote) sensor data is verified by the more precise external AIBO localization tool to measure the improvements of the common world model.

Another master student has been assigned to improve the team skills, i.e. investigate the possibilities of the pass game between two or more players. This makes use of the new common world model. Some extensions to the behavioral language have been made to facilitate communication and reasoning about team strategies, also taking into account that the wireless link may break at any time which means that the AIBOs must always be able to fall back to a completely autonomous mode. A new graphical behavioral editor has been developed. Furthermore, we hope to incorporate some of the algorithms and experience the UvA collected in the past years in the Simulation League in these behavioral extensions.

4 University of Utrecht

The main focus of the research group is on logic and multi-agent systems. The group has developed its own agent-programming language 3APL [1], which provides a logical basis for building (communicating and deliberating) agents. Other areas of research are reinforcement learning, neural networks, and genetic algorithms. Both approaches to AI are currently being tested in a number of different robots. This year's Software Project course has assigned 10 BSc students to work on various tasks. Mainly because of the changed rules for 2005 (a bigger playing field), field adaptations were made by the members of this group. We focused mainly on three different aspects:

– *Vision*. We have made two tools to enhance color detection. Firstly, we developed a tool which allows better calibration. By marking different regions with polygons, instead of pixel-wise, the color table can be created faster and easier. Secondly, we have improved our filter that corrects faulty camera input near the corners of the image.
– *Behavior*. To optimize behavior selection, we used Interval Estimation Algorithms as an initial approach. Informally stated, this approach has some resemblance to reinforcement learning, for that it allows for a statistic analysis of state-based

action selection to optimize a player's behavior. Currently we are testing this technique on the keeper's behavior. When results are promising we will extend and refine this technique of behavior selection for all team players.

– *Self-localization*. Our main effort was to integrate distance estimations in the self-localization algorithm. We found, however, that our percepts (e.g. goals and landmarks) were not sufficiently reliable for these operations. So for this to work we needed to rewrite our self-localization module and make the percepts more congruent with reality. We used a method where the distance between the percept and the robot is calculated in two ways; by checking the image for both the amount of green and the height of the goal. These two estimations can be compared to give a more reliable result.

In parallel, we are currently investigating the possibility of redesigning the cognition model, totally independent of the current base-code. Our main approach lies within the Tekkotsu framework for reasons that concern flexibility and optimalization. To allow such a shift we are extending the framework by redesigning the thread model currently available in Tekkotsu. Whereas learning will become more important in our upcoming research tracks, also embedding the 3APL agent-programming language will be one of our main research area's when the initial phase of our framework development moves to completion.

5 Saxion University of Professional Education

Within the Saxion University of Professional Education a small research group ('lectoraat SERTES') has a focus on reducing complexity of high-level and low-level aspects of ad-hoc networks. At this moment a team of 6 students is dispatched on a project to achieve the *almost SLAM challenge*. The group consists of Peter Bindels, Ronald Hemmink, Robert Jan Sanderman, Nico Assink, Thijs Emaus and Stefan Kampman.

The ambition of the Saxion group is to improve the result of the previous attempt done last year and to achieve a good competitive result in Osaka this year. Currently addressed are both an image processor to enhance recognition and new behavioral code. One of the first steps is to adapt the previous localization technique to new circumstances like field dimensions and type of AIBOs.

6 Discussion

We look forward to the RoboCup 2005 to test our ideas and learn from competitors. We are confident that our behavior based vision approach will greatly help us and improve our field play.

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