Team Report „Hamburg Dog Bots“ 2004

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Introduction

In autumn 2003 the University of Hamburg, Germany, finally received eight ERS-210A Sony Aibo Robots, just in time for the winter semester 2003/04. We started immediately to set up a new project to be able to participate in the Sony Four-Legged Robot League 2004. Due to the great number of very motivated students we decided to set up two independent teams with different starting conditions to evaluate their individual approaches. With the future possibility to join the German Team in mind, the first team started with the German Team 2003 source code as a foundation. The second team received the assignment to create a new team from scratch. Prescribed by the regulations for our type of lesson in the course of studies of computer science at the University of Hamburg the students had to organize and accomplish the task ahead on their own with only limited support. In addition to the three hours a week in the project the students had the option to spend more time on working with the robots.

Odie BrotHHers

The team that started with nothing but the OPEN-R-SDK voted to name itself "OdieBrotHHers". They divided their team into several smaller groups to deal with different aspects of developing a new RoboCup soccer team: Communication (three students), Project Management (five students), Vision (six students), Localization and Strategy (three students) and Motion (five students).
The Project Management group organized the developing effort among other things by defining the inter-object communication and introducing code conventions and rules for comments to ensure equality in programming. When it became obvious at the end of the first semester that the developed code would most probably not beat the Dog Bots, this group decided not to further try to develop a new soccer team, but to concentrate on the challenges. The results will be revealed at one of the upcoming RoboCup World Championships.

Hamburg Dog Bots

The team that started with the German Team code from 2003 decided to call themselves "Hamburg Dog Bots". The students divided their team into several smaller groups to deal with the following aspects: Communication (two students), Project Management (five students), Vision (five students), Localization and Strategy (five students) and Motion (eight students). Besides modifying the German Team code to comply with the RoboCup 2004 rules, they searched and found the following aspects to improve the German Team 2003 code.

Vision and Intention Recognition

In the Sony Four-Legged Robot League the particular object types as field lines, goals, ball and players have different specific colors. Hence methods for object recognition can be used, which process information about colors in camera images. In order to get information not only about position of objects but also about their orientation - either relative to the robot or on the field - the shape of the objects seen will be taken into account too. As a consequence it will be possible to distinguish robots from the own and adversarial team. Contours of objects are determined with contour following. To find lines, circles and robots several Hough transforms are performed. Each robot calculates the positions of seen objects relative to its own position. After that each robot sends its data to its team mates. The robots add new information to their local map of game state and, if the information is sufficient, the robots are able to determine their own position in the field. Further on they will be able to determine the position and heading of adversarial robots and act accordingly.

Motion

The Motion group discovered very fast, that other teams used faster walking styles and were very successful with them. Being the first team to get to the ball is an all-important winning factor. Fast and stable walking and several new successful "kicks" were important tasks in this group. This group tried to develop a new and improved walking engine.

The new walking engine should meet the following requirements:

- Stability: The position and orientation of the head (and with it the camera) should be affected as little as possible by the movement.
- Flexibility: The movement should perform well on a variety of surfaces.
- Extensibility: Walking sidewards and backwards and rotating should be a variation of the underlying basic motion.

The pattern of the basic movement was represented by a polygon in 3-dimensional space, which is traversed by each foot phase-delayed to each other. The movement speed can be set separately for each polygon edge. For sideward and backward motion and rotation the polygon is transformed accordingly for each leg.

The motion group started with real world experiments to get a feeling of the physical characteristics of the robots. By manual adjustment of the walking style we nearly achieved the performance of the GT2003 walking engine.

It seemed reasonable to implement a genetic algorithm for the automatic optimization of the walking style. The result of the fitness

function for a specific solution candidate is determined empirically by measuring the time for the robot to move from one penalty area to the other. The parameter domain consists of a fixed number of polygon vertices and the traversing speed along each polygon edge. The learning process was limited to forward walking only.

The motion group could only increase the forward walking speed insignificantly. The runtime required for a significant learning success would have been too long. Because of the wear of the joints reported by other teams we decided not to risk mechanical failure of the robots by prolonged learning periods.

Sometimes the resulting movement patterns were successful although the motors were not able to reach the motion speed requested by the generated parameter set. Thus the algorithm produced polygons that had only little in common with the actual performed motion, which introduced stronger dependencies on the individual physical properties of the robot and the used inverse kinematics algorithm.

Due to the limited time of the project it was not possible to optimize the sideward walk and rotation in our walking module. For these kinds of movements the walking engine provided by the GT2003 was used instead.

Behavior

First the team made an analysis of the behavior implementation in the GT2003 code. The conclusion of this analysis was that the behavior implementation in the GT2003 code was already very good. However the implemented behavior based its decisions mainly on the situation of the robot and not on the global situation.

A global case based behavior was not implemented. To implement a behavior based on global cases the team created a module that overrides the behavior graph of the GT2003 implementation when necessary.

The module was first tested using a simple set of rules that where based on the positions of the robots and the ball to force a more defensive or offensive team tactic.

The next change was the implementation of a set of emergency situations. In these situations the robots where forced to support the goalie.

After successful tests of the new module, the team needed to derive the correlations between the global situation and the actions of the robot. To achieve this goal a graph based model was made to track the behavior of the robot and the global state.
The global state is a tuple (p_1, p_2, p_3, p_4, o_f, o_g, b_p, p_b) with:

p_i the position of the own players
o_f the position of an opponent field player
o_g the position of the opponent goalie
b_p the ball position
p_b the possession of the ball

Because the opponent field players can't be distinguished the opponent's constellation is used instead of the individual positions.

The ball possession is either "own", "opponent" or "nobody". The positions are mapped to disjunctive field areas.

In the resulting graph a node represents a world state. The nodes are connected by edges representing the probability of actions to lead to another world state. The edges are updated during the tracking of the game. The graph is then used to find paths that lead to previously defined desired game situations. The graph is also used to find pairs of world states and actions that would likely result in the loss of the ball. The graph building algorithms are not implemented in the game code, but run on an external computer during test matches.

While the graph itself can't be used on the robots it is possible to derive rules for the new tactics module. The module can then use these rules to decide the next action.

Experiences During the Competitions

In 2004 we participated at the German Open in Paderborn and at the RoboCup World Championship in Lisbon. At the German Open we unexpectedly reached the 3rd place. In Lisbon we made it into the quarter finals as the only full ERS-210A team and qualified for the World Cup 2005.

At both competitions we observed several disadvantages when playing against the new ERS-7 robots. The new model not only has a faster processor, but also stronger and faster motors. For example, this sometimes resulted in the goal keeper being pushed into the own goal together with the ball it was holding. The ERS-7 is also able to reach a higher walking speed.

Due to the improved game tactics we were still able to defeat some of the teams using ERS-7, especially at the German Open where the motion engines were obviously not yet optimized for the new robots. At the World Championship the programs for the new robots were further optimized and became harder for us to play against.

Student Research Papers

During the project several project-, studies-, bachelor-, and diploma-thesis evolved from different problems:

Jana Passow: *Geometrieidentifikation aus den Kamerabildern mobiler autonomer Systeme in der Sony Fourlegged Robot League.* Diplomarbeit, Fachbereich Informatik, Universität Hamburg. June 2004.

Peter Roßmeyer: *Teamwork exemplified by the Four-Legged League in RoboCup.* Studienarbeit, Fachbereich Informatik, Universität Hamburg. To appear in spring 2005.

Valerij Krichevskyi: *Analyse und Implementierung der 'Variable Lighting Challenge' der Four-Legged-Liga im RoboCup.* Studienarbeit, Fachbereich Informatik, Universität Hamburg. To appear in spring 2005.

Malte-Nils Sörensen: *Autonomes zweibeiniges Stehen von Sony Aibo Robotern durch Einbettung von Beschleunigungssensoren.* Baccalaureats-Arbeit, Fachbereich Informatik, Universität Hamburg. To appear in spring 2005.

Conclusion and Future Work

Because of the limited available time and computer resources the project proved to be rather challenging for both teams. The students had to familiarize themselves with both the programming language and the OPEN-R-SDK. Additionally the Hamburg Dog Bots team worked itself through the German Team source code, which has grown to be very complex over the last years. Besides establishing a project-management group as required, both teams organized themselves into several smaller groups to each look at a specific field of interest like motion, vision, communication, localization and strategy. This proved to be a good approach for the OdieBrotHHers to cover all aspects of creating a new team. Being short in time dividing their resources was not as good as an idea for the Hamburg Dog Bots. After evaluating the German Team source code, the team quickly realized that they had to focus on a narrower range of topics.

Our overall goal is to include more collaborative behavior in future work. By means of integrating socionic and game theory the robots should play as a team instead of playing antagonism. Another aspect of future work relates to the little interest of women in the Sony Four-legged League. Besides including socionic aspects like communication and cooperation in the behavior of the soccer-playing robots we will develop new additional scenarios to foster interest of women in robotics.

Pointers to Relevant Publications

Our relevant publications as well as videos and pictures are available on our website: http://www.informatik.uni-hamburg.de/robocup/