

Nao Team Humboldt 2010

The RoboCup 3D-Simulation Team of Humboldt-Universität zu Berlin

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1 Introduction

The Nao Team Humboldt was founded at the end of 2007. It consists of students and researchers working at the Humboldt-Universität zu Berlin, coming from a number of different countries during the last years, in particular from Germany, Russia, Egypt, China, Iraq, and Iran.

We have a long tradition within RoboCup by participation in the simulation league (2D and 3D), in the humanoid league, and in the standard platform league (Aibo and Nao) in the past. We have won second place in 3D league in Lisboa 2004, and now we want to participate again in order to have closer connections between real and simulated robotic soccer. This has become very interesting after 3D league has decided to use the Nao model. We will use the same concepts and even programs (as far as possible) for both, real and simulated Nao (cf. section 3).

We have been participating in the Four Legged league as a part of the successful GermanTeam in recent years. Thus, we can draw upon many years of experience in the area of robotic soccer. The software architecture was developed from scratch. Additionally, we developed several tools such as RobotControl and MotionEditor for testing, debugging or for creating new motion nets.

We started with NAOs in May 2008 and achieved the 4. place in the competition at Suzhou 2008. We achieved 3. place in technical challenge at Graz 2009. A short overview about our implementation is given in section 2.

Our general research fields include agent oriented techniques and machine learning with their applications to cognitive robotics. As our record shows, our results are recognized outside RoboCup as well. In connection with the NAOs we investigate especially

- Relationships between simulated and real robots (section 3)
- Flexible motions using sensor feedback (section 4)
- Perception using Constraint based techniques (section 5)
- Gesture recognition (section 6)

Our investigations concerning simulation and reality have a special focus on 3D Simulation League. We use for both, Standard Platform League and 3D Simulation League, a common core of our program. Therewith, we hope to foster the cooperation between the two leagues and to improve both of them. Besides that, we want to transfer some strategic concepts developed for the 2D simulation league.

Since Standard Platform League and 3D Simulation League use the same robot — Nao from Aldebaran Robotics, a lot of work is being repeated in the different leagues while solutions for the same (or at least similar) issues exist in another league. Designing and implementing a good robot simulator is a difficult and time consuming task, so it makes sense to use and contribute the RoboCup 3D simulator. So far, we have developed accelerometer and image perceptor for SimSpark and contributed to the RoboCup community.

2 Implementation Outlines

Since the Humboldt-Universität has a long history in RoboCup, there is a lot of experience and already existing code (C++), especially from the GermanTeam with its module based architecture. Our code is divided into a part which is independent of the environment, i.e., the Core, which can run in any environment, and a specific part, which is applied to the particular platform. Besides the real robot we use Webots and SimSpark (3D Simulation league), the common core allows for uncomplicated usage of code in the simulation, too, cf. section 3. Debugging code can be switched on/off during runtime. Debug results are transferred over the network and monitored/visualized using RobotControl, a robot data monitoring and debugging tool, which is implemented in Java to be used on arbitrary platforms.

Motions are implemented by keyframe techniques and inverse kinematics. Keyframe nets were developed through teaching and hand coding with the help of our motion editor framework. For parameterized dynamic motions as omnidirectional walks and kicks we use and investigate inverse kinematics and the sensor feedback cf. section 4.

Behavior is executed through a hierarchical state machine, known as XABSL (Extensible Agent Behavior Specification Language) [1]. The behavior code generation was supported by the related editor, debugging, and visualization tools. It allows layered usage of different behaviors, from very low-level motions to high-level cooperative team skills. Each option in the behavior tree decides the running time of it's direct active sub-options in case of being activated itself, though each one takes care of it's own timing. Furthermore options have some internal state criteria, used as inter-option communication means, mainly utilized by sub-options and their super options. Each option can also have a possible transition condition, through which along with the option's state propagation, the active behavior-switching in any decision level can be safely accomplished.

The recent perception model in 3D is based on already "preprocessed" information provided by the soccer server. For the real robots, we have developed basic methods as well, which might be useful in the future 3D league. Basic image processing as color classification is performed using a 80x60 pixel grid. Object detection (ball, goals, lines, robots) applies classical methods, e.g., region growing. The camera matrix is computed by the kinematic chain (alternative approaches using constraints are under investigation, cf. section 5). Constraints are already used for navigation and world model as well as particle filters. A Kalman filter is applied to generate a local ball model. Global ball positions are communicated between players to coordinate team behavior.

3 Simulation and Real Robots

As a common experience, there are big gaps between simulation and reality, especially with regards to basic physics with consequences for low level skills in motion and perception. We investigate the relationships and possibilities for method and code transfer. Consequences can lead to better simulation tools, especially in the 3D Simulation League. It was our plan to participate in both, Standard Platform League and 3D Simulation League with the common core of our program. Unfortunately, we were not qualified by the SPL committee (one communicated reason was a malus for teams which have the chance to participate in other leagues). Nevertheless, we will continue our work in both leagues. As stated already, therewith, we want to foster the cooperation between the two leagues and to improve both of them.

When compared to real Nao robots, some devices are missing in the SimSpark, as LEDs and sound speakers. On one hand, we added some devices, e.g., camera, accelerometer, to simulate the real robot. On the other hand, we can use a virtual vision sensor which is used in 3D simulation league instead of our image processing module.

The key point to success is narrowing the gap between simulation and reality. There are some researchers who have already tried to achieve this, but there are only few successful results so far.

Our plan is to analyze data from sensors/actuators in simulation and from real robots at first and then to apply machine learning methods to improve the available model or build a good implicit model from the data of real robot.

So far, we have developed walking gaits through evolutionary techniques in a simulated environment [2, 3]. Reinforcement Learning was used for the development of dribbling skills in the 2D simulation [4], while Case Based Reasoning was used for strategic behavior [5, 6]. BDI-techniques have been investigated for behavior control, e.g., in [7, 8].

4 Flexible Motions

Fixed motions as keyframe nets perform well in a very restricted way and determinate environments. More flexible motions must be able to adapt to different conditions. There are at least two specifications: Adaption to control demands, e.g., required changes of speed and direction, omnidirectional walk, and adaptation to the environment, e.g., different floors. The adaptation of the kick according to the ball state and fluent change between walk and kick are another examples.

Different control commands can be satisfied by parameterized motions and by online calculations. For the latter, we investigate inverse kinematics. Adaptation to changing conditions requires feedback from sensors. We experiment with the different sensors of the NAO. Especially, adaptation to the visual data, e.g., seen ball or optical flow, is investigated. Problems arise from sensor noise and delays within the feedback loop.

We have investigated different Optimization and Machine Learning approaches, as evolutionary approaches [9, 2] and recurrent Neural Networks [10] for Aibos and humanoid robots, and - as mentioned earlier - Reinforcement Learning (RL) with applications for the 2D simulation league [4]. Recently, another PhD thesis with focus on RL for humanoid robot walking is being written.

At present, some of our developed motions can be watched as videos on our web site <http://www.naoteamhumboldt.de/category/media/>.

5 Perception

We investigate the application of Constraint based techniques for navigation, and compare the approach to classical Bayesian approaches as Kalman filters and Monte-Carlo methods. Kalman filters make certain assumptions about the environment (linearity of the model, Gaussian noise), Monte-Carlo methods as particle filters are restricted by high computational demand and thus, low dimensionality. We have investigated these methods under various perspectives in the previous years [11–18] including missing information [19]. Constraint techniques have to handle inconsistent data, but can be advantageous whenever ambiguous data is available [20]. They are computationally cheap using interval arithmetic, and they can be easily communicated allowing for cooperative localization [21–26].

Classical approaches are prone to error propagation (e.g. from camera matrix over self localization to global positions of other objects). Using constraints, all related parameters (e.g. kinematic chain, camera matrix, positions) can be connected by related constraints and the common solution can be calculated by propagation techniques, [27–29].

Constraints are built by image percepts from flags, goals, lines and other objects (even dynamical ones like ball and other players) [23]. They are able to deal with missing information [19] as well. Other sensors such as joint sensors lead to constraints for the camera matrix. Further constraints can use communicated information and past information, e.g., object speed. Each information can be used to constrain the related parameters. The shape of the constraint is determined by the type of information and the expected sensor noise. We use constraint propagation (interval arithmetics) for further restrictions of possible values of the parameters, as for positions [27, 30, 29].

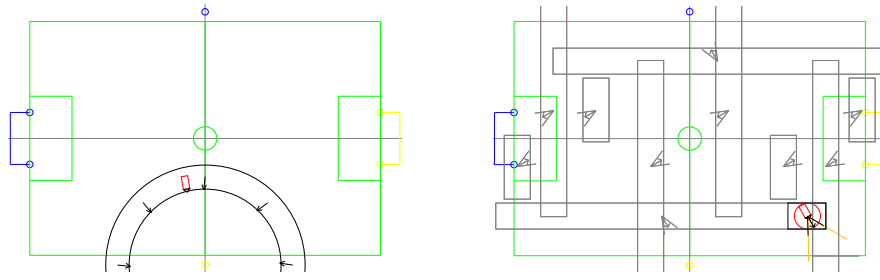


Fig. 1. Both figures show constraints, generated from percepts (pictures show the algorithm on an Aibo field). Left: a circular constraint as generated from flag percepts. Right: a line constraint, generated from line percepts.

Recent investigations and experiments deal with the treatment of inconsistencies (e.g. by ghost percepts) and further increase of performance. Furthermore we developed and tested a constraint-based player model.

6 Gesture Recognition

In order to realize intuitive interaction and communication between humanoid robots and people, we developed a system that can visually recognize dynamic arm gestures performed by a person [31]. The algorithm has been implemented on the NAO using URBI and an optimized version of our original algorithm is tested with a camera-based computer system [32]. Both supervised and unsupervised learning of gestures has been tested. Methods include adaptive color-based tracking of face and hands [33], Viola-Jones detector, and Hidden-Markov Models. The algorithms could also be extended to realize gesture-based robot-robot interaction. The results of these studies might be interesting for communication between in RoboCup in the near future.

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