Berlin United - NaoTH 2014

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1 Introduction

Our team is part of the multi-league joint research group *Berlin United* between the RoboCup research group of the Humboldt-Universität zu Berlin and the Freie Universität Berlin (FUmanoids, KidSize League). The research group *NaoTH* was founded at the end of 2007 and consists of students and researchers at Humboldt-Universität zu Berlin. The team is part of the research Lab for Cognitive Robotics at Humboldt-Universität which is headed by Prof. Verena Hafner. The team was established at and evolved from the AI research lab headed by Prof. Hans-Dieter Burkhard, and is led by Heinrich Mellmann and Marcus Scheunemann. At the current state we have one PhD student and about five Master students in the core team. Additionally we provide courses and seminars where the students solve tasks related to RoboCup and other problems of Cognitive Robotics and AI. We have a long tradition within the RoboCup of working in the *3D Simulation League* and in the *Standard Platform League (SPL)*, where we have been part of the GermanTeam in the *Four-Legged League* that won the world championship three times.

We started with *Nao*s in May 2008 and achieved the fourth place at the competition in Suzhou 2008. In 2010 we participated for the first time simultaneously in SPL in Simulation 3D with the same code. In the 3D Simulation we won the German Open and the AutCup competitions and achieved the second place at the RoboCup World Championship 2010 in Singapore. In 2011 we won the Iran Open competition in SPL. In 2011 we started a conjoint team *Berlin United* with the FUmanoids from Berlin who participated in the KidSize League. In the worldcup 2012 in Mexico we won the technical challenge with an extension for the SimSpark Simulator, used in *3D Simulation League*, to get closer to achieve our long-term goal to narrowing the gap between the simulation and real robots league (section 3).

With our efforts in these three leagues, we hope to foster the cooperation between these leagues and to enhance results in all of those leagues with perspective change. In cooperation with FUmanoids we applied for a RoboCup project to investigate a common communication protocol to hold matches with different robot platforms and software in one team. Another RoboCup project dealt with the topic of an extension for SimSpark for SPL. We informed about results of these extension during the symposium 2013 in Eindhoven.

Our general research fields include agent-oriented techniques and machine learning with applications in cognitive robotics. As our record shows, our results are recognized outside RoboCup as well. Our current research projects focus among others mainly on the following topics:

- Narrowing the gap between simulated and real robots (section 3)
- Software architecture for an autonomous agent (section 4)
- Dynamic motion generation (section 5)
- World modeling (section 6)

In section 2 we summarize our general contributions to the RoboCup community. Section 7 gives a brief overview on our other related research topics. We will describe them briefly in the next sections, please refer to our recent publications [19, 11, 4, 21, 25, 23, 24, 20, 15, 3] for more details.

2 General Contribution to the Community

We have been contributing to the RoboCup community for more than ten years in various ways. The exchange of ideas and experiences is an important aspect which we try to foster by organizing workshops, courses etc..

Robotic Workshops ("RoBOW"). In addition to some smaller workshops, we organized two major robotic workshops in Berlin from February 25-27 and from May 20-22, 2011. Six teams participated from SPL and KidSize League. The RoBOW'12.1, 12.2 and 12.3[1] took place in February, May and December 2012 respectively. We had 8, 7 and 8 attending teams with around 40 participants. Based on this great success we planned that also other universities arrange the workshop to attract more teams in other parts of Germany and Europe. Nao Devils Dortmund organized the RoBOW'13.1 in Dortmund from February 22 till 24, where a team from the Netherlands was able to participate easily. Because of major league changes, three RoBOWs are planned for the year 2014 beginning in March.

RoboCup Projects. In 2011 we were awarded a RoboCup grant for designing a software architecture which can be used on different platforms, e.g., Nao, Simspark. In the year 2012 we received a grant for the joint project *Common Communication Protocol* (cf. section 4) together with FUmanoids and 2013 we were granted for an extension for SimSPark for SPL (cf. section 3).

Berlin United. We formed a conjoint team with the FUmanoids in 2011. This fusion was a result of a long-standing cooperation between our teams which has rapidly grown in the recent years including joint test games and workshops. We hope to achieve strong synergy effects for our efforts within RoboCup and closer cooperation between our leagues.

[1] further workshop information can be found at our homepage http://naoth.de and http://robow.de

Courses. Our team is heavily involved in the teaching process within our department. SPL and Simulation 3D (S3D) scenarios are used for demonstrations and practical exercises in the related courses (AI, Cognitive Robotics, Human Robot Interaction, Embodied Artificial Intelligence). Special intensive workshops for robotic beginners took place in universities and schools. Beyond that we offer special courses and seminars on RoboCup which involve students actively in the work within our team. We are also offering possibilities for Bachelor-, Master- and PhD theses related to projects within our team.

3 Simulation and Real Robots

We foster the cooperation and transfer of skills between real and simulated robots. Because of differences between real and simulated physics, the common use of basic skills still raises serious problems, while higher level strategies can be transferred easier.

Participation in SPL and 3D Simulation with the common core of our program. This is made possible by our common architecture [21], which is currently used by our joint team Berlin United within three leagues: SPL, S3D and Humanoid KidSize and by the *Dutch Nao Team* from *Amsterdam* also within SPL.

Extension of SimSpark by adding missing devices like a camera or an accelerometer, to simulate the real robot. By this we are pushing the S3D towards the real world and possible applications as a simulation for real robots.

SPL simulator based on SimSpark. It simulates the environment of SPL and allows the use of virtual vision as in 3D simulation. This allows to perform isolated experiments on low level, e.g., image processing, and also on high level, e.g., team behavior. This simulator can be downloaded from our Berlin United repository on *github*[2]

Use of Kinect as a low cost motion capture system. It allows us to measure the quality of simulation results not only by the sensor data of the robot but also by a 3D point cloud. Furthermore, the parameters of the simulator are optimized by Genetic Algorithms. This is done by using the difference between the simulated and the real robot movements as fitness. Detailes and results will be published soon.

4 Infrastructure

Architecture. An appropriate architecture (framework) is the base of each successful heterogeneous software project. AI and robotics related research projects

[2] SPL Simulator source code and Ubuntu package: https://github.com/BerlinUnited/SimSpark-SPL

are usually more complicated, since the actual result of the project is often not clear. A strong organization of the software is necessary if the project is involved in education. Our software architecture is organized with the main focus on modularity, easy usage, transparency and easy testing. Please refer to our recent publication [21] for more details.

Communication Protocol. Together with the *FUmanoids* we developed a minimal common communication protocol which aims to enable inter-team communication, in particular for mixed teams.

Simple Soccer Agent We developed and published a simple framework for an easy start in the 3D simulation league, downloadable from our website[3].

RoboNewbie. Another approach for educating basic robotic skills is RoboNewbie. The Java-Framework is based on SimSpark and was successfully used within several workshops

XABSL Editor. The *XabslEditor*[4] is a graphical editor for the "Extensible Agent Behavior Specification Language" XABSL[5] which was developed by our team several years ago. It is implemented in Java and numerous teams around the world are using XABSL together with our *XabslEditor*.

5 Dynamic Motion

Neural Walk. We are experimenting with alternative approaches for motion generation on Nao. Inspired by the experiences of the related research group *NRL*[6] we implemented a walking algorithm based on a Neural Network. In our first experiments the neural approach used 1/3 less energy compared to our current walk.

Walk and Dynamic Step Control. We implemented a stable and flexible onmidirectional walk based on inverse kinematic and Inverted Pendulum. The center of mass is controlled by on-line minimization, this allows us to control feet more freely. The step trajectory can be varied according to the stability; and the relation between the feet can be specified on-line for special movement. Furthermore, the dynamic step control is realized for ball handling, i.e., dribbling, which is a key ability of a soccer player.

Dynamic Kick. Our dynamic kick is able to adapt on-line to the changes of the desired kicking direction as well as to the moving ball. For detailed description of the implementation, please refer to [24, 20]. Videos showing some experiments performed on the real robot can be found on our homepage.

3 http://www.naoteamhumboldt.de/en/projects/simple-soccer-agent/
4 *XabslEditor* is available at http://www.naoth.de/en/projects/xabsleditor/
5 http://www.xabsl.de/
6 http://www.neurorobotik.de

6 Perception and Modeling

One of our major research topics is world modeling. In particular, we consider it as being closely connected to perception and motion control, i.e., a good world model depends on active exploration of the environment (active attention control) and the adaptive perception which focuses on the information currently needed (passive attention control).

Adaptive Object Recognition. Although, this is one of the oldest topics in RoboCup, it is still far away from being sufficiently solved. Currently we are working on dynamic recognition of the colors and detection of the objects based on geometrical features, to make the perception more independent from lightning conditions.

Local Modeling. [18] Many tasks can be solved using only partial information like local relations between objects. For example, the decision whether the ball is outside the penalty area can be made simply by the local relation between the ball and the white line of the penalty area border without knowing the whole environment, e.g with less computational effort. Local models for Lines and Goals are already implemented and used.

Local Obstacle Model. As part of the local modeling we are working on local obstacle models, e.g., an obstacle model centered around the ball. Thereby, the obstacles, e.g., opponents around the ball are modeled. This view allows for an easier handling of ball-fighting situations. The ball obstacle model is implemented and used.

World Modeling. A model of the world consists of a network of local models connected by relations between them. This approach will allow for partial updates, pointing attention to some important parts of the model, e.g., a line, late integration of inconsistent information, e.g., a perceived line which does not fit to the actual state of the world is stored into a separate local model and maybe reused later. Another important factor is the treatment of errors. The classical approaches treat the sensor noise and ambiguity of observations as the same. We believe, that treating them separately, i.e., sensor noise is modeled by local models and ambiguity is resolved by the global world model, may lead to much more stable results.

Constraint Self-localization. We investigate constraint based techniques as alternatives to classical Bayesian approaches for navigation. We have investigated these methods under various perspectives in the previous years [17, 14]. Constraint techniques have to handle inconsistent data, but can be advantageous whenever ambiguous data is available [9], e.g., in case of unicolored goals. They are computationally cheap using interval arithmetic, and they can be easily communicated allowing for cooperative localization [5–8].

7 Further Related Research

There are several further research projects in progress involving *Naos*. Some of these topics are quite interesting for the ongoing enhancement of the RoboCup Competitions.

Strategic positioning of robots using Voronoi diagrams. Strategic positioning in robot soccer is a crucial for team play in robot soccer. We used Voronoi diagrams to let the robot calculate trajectories for obtaining specific positions. These calculations take other robots and the environment into account to avoid obstacle and using optimal paths [11]. Because of our focus on building SimSpark for SPL (section 3), we were able to test this framework with SPL rules in a simulated environment in advance.

Grasping with additional tactile Sensors. Human grasping integrates a lot of different senses. In particular, tactile sensing is very important for a stable grasping motion. When we lift a box without knowing what is inside, we do it carefully using our tactile and proprioceptive senses to estimate the weight and thus, the force necessary to hold and to lift this box. We have implemented an adaptive controlling mechanism which enables a robot to grasp objects of different weight. Thereby, we only use the proprioceptive sensors like positions and electric current at the joints and additional force sensors at the end-effectors providing the *Nao* with tactile feedback. [19, 16, 4]

Attentional Models. The skill of focusing ones attention to a certain aspect of the environment and excluding others is an important way of detecting the current context and reducing processing and memory load. Two agents can also have a joint attention [12]. In experiments with the humanoid robot Nao, an attentional model together with an Ego-sphere was implemented and tested during a human-robot interaction experiment [2]. In RoboCup, this skill allows to quickly find salient regions, e.g. other players moving or the ball.

Body Maps and Pointing. We performed random body babbling experiments on the Nao, where the Nao learned the relationship between a certain arm posture and the visual information for seeing its own hand [22]. Using an internal simulation, this could then be applied to moving the hand to a desired position in space without the need of any inverse kinematics [1]. In a second experiment, we showed that using this technique, the robot can perform pointing gestures to objects outside the field of reach based on the learned mapping [10]. For RoboCup, this could help to adjust motions (e.g. kicking a ball) perfectly to the given robot hardware, and also to perform gestures for communication between the robots.

Behavior Recognition. For interacting with the other robots on the field it can be advantageous to detect movement patterns of the opponents and predict where there will walk to. The goal of the experiment was to detect the other robots visually and model their movement on the soccer field over time. This model was learned by different kind of learning algorithms and their performance was compared to a simple speed based model. A lot of research questions are still open but it could be shown that even for a short prediction time the knowledge based learning could perform better than simply propagating the speed of the other robot [13].

Most Recent Publications (without technical papers)

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3. Burkhard, H.D.: Agent oriented techniques for programming autonomous robots. Fundam. Inform. 102(1), 49–62 (2010)
4. Cotugno, G., Mellmann, H.: Dynamic motion control: Adaptive bimanual grasping for a humanoid robot. In: Proceedings of the Workshop on Concurrency, Specification, and Programming CS&P 2010. vol. Volume 2. Börnicke (near Berlin), Germany (September 2010)
5. Göhring, D.: Constraint based world modeling for multi agent systems in dynamic environments. Ph.D. thesis, Humboldt University Berlin (2009), http://edoc.hu-berlin.de/docviews/abstract.php?id=30348, [Online: Stand 2010-05-23T15:08:02Z]
6. Göhring, D., Mellmann, H., Burkhard, H.D.: Constraint based belief modeling. In: Iocchi, L., Matsubara, H., Weitzenfeld, A., Zhou, C. (eds.) RoboCup 2008: Robot Soccer World Cup XII. Lecture Notes in Artificial Intelligence, Springer (2008)
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12. Kaplan, F., Hafner, V.V.: The Challenges of Joint Attention. Interaction Studies 7(2), 135–169 (Jan 2006)
13. Krause, T.: Erfahrungsbasierte Lernmethoden zur visuellen Trajektorienvorhersage humanoider Roboter . Diploma thesis, Humboldt-Universität zu Berlin, Institut für Informatik (2011)
14. Mellmann, H.: Active landmark selection for vision-based self-localization. In: Proceedings of the Workshop on Concurrency, Specification, and Programming CS&P 2009. vol. Volume 2, pp. 398–405. Kraków-Przegorzaly, Poland (28–30 September 2009), http://csp2009.mimuw.edu.pl/proc.php
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