BreDoBrothers

Team Description for RoboCup 2008

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1 Introduction

The *BreDoBrothers* are a RoboCup team that is a cooperation between the University of Dortmund, the University of Bremen, and the DFKI Lab Bremen. The team consists of numerous undergraduate students from both universities as well as researchers from the three institutions. The latter have already been active in a number of RoboCup teams such as the GermanTeam, the Microsoft Hellhounds, and the Bremen Byters (all Four-Legged League), B-Human and the Doh!Bots (Humanoid Kid-Size League), and B-Smart (Small-Size League).

2 Relevant Achievements in RoboCup

The senior team members have already been part of a number of successes, such as winning the RoboCup World Championship twice with the GermanTeam (2004 and 2005), winning the RoboCup German Open twice (2005 by the Microsoft Hellhounds, 2007 by the GermanTeam), winning the Dutch Open and US Open (2006, Microsoft Hellhounds), and winning the Four-Legged League Technical Challenge three times (2003 and 2007 by the GermanTeam, 2006 by the Microsoft Hellhounds). The activities also resulted in a vast number of publications [1, 2]. In addition, the GermanTeam framework is the most used software basis in the real-robot leagues of RoboCup. In recent years, more than 30% of the teams in the Four-Legged League built their systems on top of it.

In parallel to these activities, the BreDoBrothers started a joint team in the Humanoid League which participated in RoboCup 2006. The software was as far as possible based on previous works of the GermanTeam [3]. Because of difficulties in developing and maintaining a robust robot platform across two locations, this team was temporarily split into two single Humanoid teams. The DoH!Bots from Dortmund as well as B-Human from Bremen participated in RoboCup 2007; B-Human reached the quarter finals and was undefeated during round robin. Figure 1 shows all robot models that have been developed so far. Figure 2 shows the simulator used to support the software development.

3 Research Goals

The cooperative and competitive nature of robot soccer in the Standard Platform League provides a suitable test bed for a broad research area. The research of our team is mainly

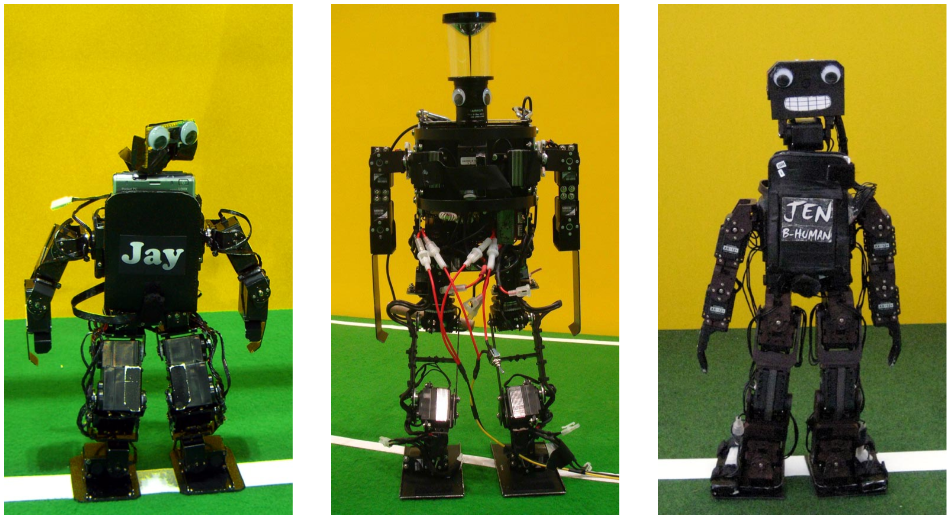

Fig. 1. Self-constructed humanoid robots (from left to right): Jay from the first BreDoBrothers team, a DoH!Bots robot, and Jen from B-Human.

focused on Computer Vision, Probabilistic State Estimation, and Machine Learning. Naturally Biped Walking is also thoroughly addressed.

3.1 Computer Vision

In the field of computer vision, we presented an algorithm for performing structure preserving non-linear noise reduction on computationally constrained robotic platforms [4], and a set of techniques to improve color based vision on embedded platforms (color table generalization based on an irradiation model, automatic vignetting correction) [5]. The work on automatic image vignetting correction has been further extended to take into account differences in color response from different cameras in a team of robots, and the optimization technique has been refined with the adoption of Evolutionary Strategies [6].

3.2 Probabilistic State Estimation

Our research is mainly focused on Bayesian filters, we have presented a vision-based Monte Carlo localization system [7], and our approach based on the detection of field features without using artificial landmarks has won the “almostSLAM” Technical Challenge at RoboCup 2005 [8]. The usage of particle filters for localization and tracking on humanoid robots has been shown in [9].

Our interest is also in the field of cooperative object tracking and sensor fusion, where we have presented a distributed approach to particle filtering to model the ball position collectively as a team [10]. Opponent player tracking is a generalization of ball tracking, made more complex by the data association problem (all players in a team look identical) and an increased difficulty in visual recognition and distance measurement due to the complex shape of the robots. As a first approach we dealt with cooperative robot tracking

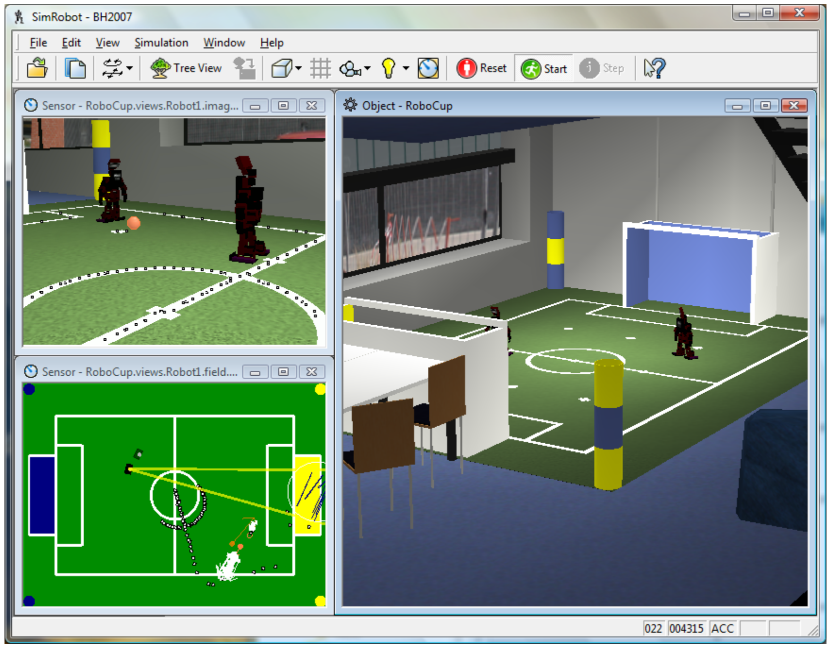

Fig. 2. The physical simulator SimRobot simulating B-Human robots playing soccer in one of our labs, displaying the camera image and the world model of one of the robots.

using a bank of particle filters dynamically allocated depending on the estimated number of players in the field [11]. A Kalman filter-based approach for non-cooperative, egocentric tracking of multiple robots had been developed contemporaneously by [12].

3.3 Machine Learning

Many algorithms in robotics contain parameterized models. The setting of the parameters typically has a strong impact on the quality of the model. Finding a parameter set which optimizes the quality of the model is a challenging task especially if the structure of the problem is unknown and can not be specified mathematically, i. e. the only way to get the "function value" for a certain parameter set is to try them out. For optimizing these "black box" problems, different machine learning approaches have been used.

Controlling the robots' legs in order to walk for example is typically done by defining trajectories for the foot movement. The parameters (e.g. step height, step length, timings etc.) of the trajectories affect the stability and speed of the walking gait. Our team has published several autonomous learning techniques for the gait optimization in [13–17].

Another application of machine learning has been presented in the previously mentioned optimization of the model used for image vignetting correction [6].

3.4 Biped Walking

Biped walking is significantly different from quadrupled locomotion and one of the mayor research topics related to humanoid robots. Our current research yielded two different approaches to this task.

The first approach consists of a generally formulated open-loop control based on body trajectories optimized with the Machine Learning techniques mentioned above. The alternative approach computes inverted-pendulum model gait patterns through a closed-loop control using ZMP sensor measurements.

Both are developed in parallel and have yet to be fully evaluated in their performance on the Nao.

4 Approach

Since the preparation time for RoboCup 2008 using Naos is quite limited, the main focus lies on porting existing software to the Nao. The starting point was the code base of B-Human, which is already able to play soccer with humanoid robots, and uses the new, more efficient and far more flexible architecture of the GermanTeam 2007 [18]. Since the code of B-Human is highly optimized for the rather slow processor of a PDA, and the Nao will provide significantly more computing power, there is enough room for integrating additional and improved algorithms from the other code bases that we have developed (Doh!Bots, GermanTeam, Microsoft Hellhounds), as well as continuing our research mentioned in the previous section.

The main research topic until RoboCup 2008 is developing two-legged motions for the Nao. On the one hand, this means developing kicks and getup motions, and on the other hand a fast and stable gait. Two different approaches are described above, the online generation of ZMP based walking patterns and learned static trajectories. Based on the knowledge and experience in optimizing gaits for both four-legged [13–15] and humanoid robots [16, 17], the former gait planning approach was extended for the Nao. It is our aim to further extend the approach of optimized pre-calculated trajectories to dynamically alter those to achieve stable walk and kicking motions. In order to adapt the robots motion we utilize the foot pressure sensors and the inertial sensors to determine stability criterions.

5 Summary

With our achievements in the Four-Legged League and two years of experience in the Humanoid League we are confident that we can establish a team that is competitive in the Standard Platform League at RoboCup 2008, and that provides significant input to the scientific community. Based on the current software systems we already have, we will quickly establish the Nao as the new standard platform for our robotics research.

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