# Bremen Small Multi Agent Robot Team (B-Smart) Team Description for RoboCup 2005

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**Abstract.** This paper describes the current state of development and future plans of the B-Smart Small Size team. Amongst other things, it will give an overview about the existing B-Smart robot platform, explains the techniques used for behaviour control, and describes the use of a physical robot simulator.

## 1 Introduction

The B-Smart team is a student *RoboCup* project at the Universität Bremen that currently consists of 20 student members and four tutors (all listed at the end of document). The overall goal of this project is to build a robot team that can compete in the RoboCup tournaments. So far, B-Smart has already participated in the German Open 2003 and 2004 and the RoboCup 2003 and 2004. Upcoming competitions this year will be the German Open 2005 and the RoboCup 2005 in Osaka, Japan. A big goal for the current B-Smart team is a good result at the RoboCup 2006 right here in Bremen.

## 2 B-Smart Robot Platform

At the RoboCup 2003, a prototype of a new designed robot platform similar to the *FU-Fighters*' design of 2003 [1], which is capable of omni-directional motion, has been successfully tested. In 2004, the old B-Smart architecture has been completely exchanged for a team of robots of this new architecture. These robots are still in use in 2005.

### 2.1 Mechanical Design

There were several requirements for a robust platform and it was decided to use some of the well known RoboCup teams as examples.

First of all, an omni-directional drive, which is capable of fast moving and easy control, was a necessity. Linear speed of $2.0 - 2.5$ $m/sec$ and an accordant acceleration are common among the successful teams in RoboCup Small Size competitions. Omni-directional motion can be achieved with three or four wheels

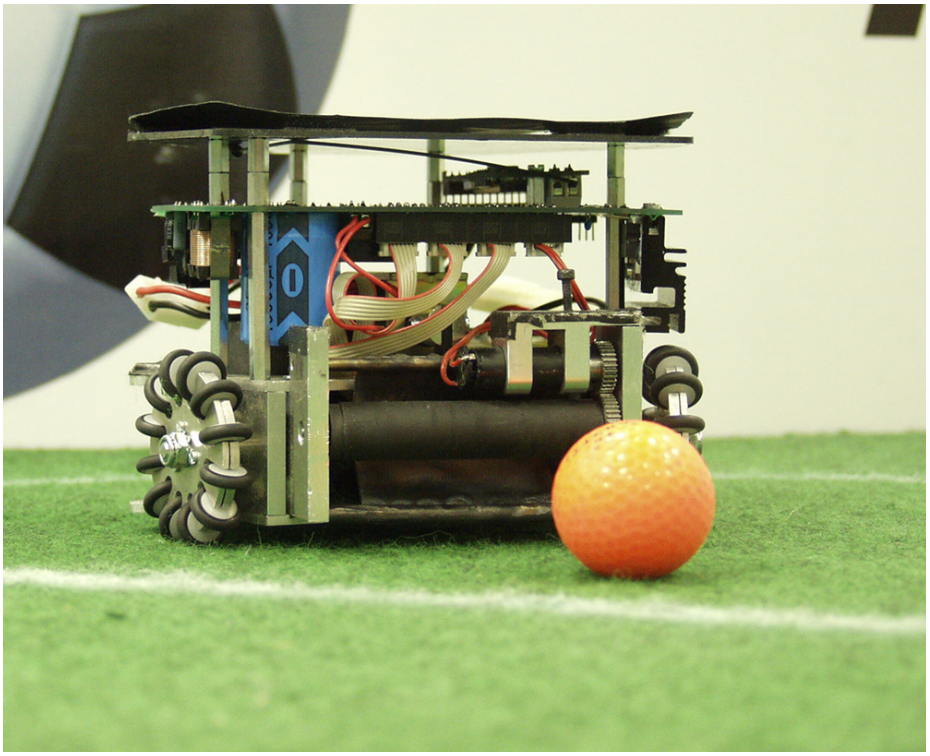


**Fig. 1.** Current B-Smart robot

which are arranged in a triangle or rectangle. Several variations are also possible. The B-Smart robots have three wheels in an arrangement which is optimised for straight forward motion, since the wheels are not aligned in uniform angles. Using this design, it is possible to achieve high speed in forward directions while moving sideways is a bit less precise and slower, but still reasonable in comparison to robots with a differential drive. With a wheel-diameter of about 54 $mm$, a 9.1:1 gear, an estimated motor speed of 6500 $rpm$ and an angle of the front wheels of $150°$ a theoretical top speed of about 2.02 $m/s$ is possible. Unlike several other teams, it was decided to build appropriate proprietary wheels, which are again similar to the FU-Fighters' approach. The advantage is a higher friction on the field. The usage of *Faulhaber* DC-motors is a reasonable choice of most teams. These motors are equipped with 9.1:1 planetary gears.

A solenoid based kicker as well as a dribbling device to hold the ball at a defined position have also been integrated.

The chassis is built out of laser cut aluminium plates and integrates pockets for the accumulator batteries and other hardware components. This design is very lightweight and easy to manufacture. We are currently experimenting with new hardware to be added to this architecture design in order to improve the performance. For example, an ultrasonic sensor could detect a passed ball much faster than the vision system and so improves the passing capabilites of our team.

### 2.2 Electrical Design

The electrical components are built around a 16 MHz Fujitsu MB90F594A micro-controller. A Radiometrix transceiver-module communicates via a one-way radio link with the PC. The micro-controller interprets and executes motion commands sent by the control software on the PC. Information about the revolutions per minute of each motor is integrated with a local PID control.

## 3 Software Architecture

The whole control software splits up in stand-alone components which communicate over UDP network sockets. There is a component for each different task. This includes vision, building a representation of the world, agent control and radio transmission.

Due to the large field size, the usage of more than one camera is required to do appropriate observations on the field. Two Sony fire-wire cameras are used by B-Smart. They are capable of capturing 30 frames per second. The percepts from the two different points of view are combined to provide an integrative world model, which is then distributed to the agents. To achieve a robust tracking of own robots, the *Butterfly* scheme described in [2] is used to localize and distinguish all robots. Our vision system is capable to handle quite different lighting conditions. For example in our laboratory, it is possible to track the robots at a light intensity of about 280 *lux*, which is only the standard ceiling lighting without any extra spotlights.

The software agents controlling the robots are running completely independent from each other. They all use a common description of the world (respectively the field and all the objects on it) in which they act. When an agent has made a decision e. g. based on the behaviour architecture described later, the commands are transferred to a server process which integrates all commands from all agents to send them via the radio link to the accordant robots.

## 4 Behaviour Control

To control the agents, a behaviour-based architecture is used that integrates existing potential field approaches concerning motion planning as well as the evaluation and selection of actions into a single architecture. This combination allows, together with the concept of competing behaviours, the specification of more complex behaviours than the usual approach which is focusing on behaviour superposition and is mostly dependent on additional external mechanisms.

### 4.1 General Approach

Artificial potential fields, originally developed by [3], are a quite popular approach in robot motion planning, because of their capability to act in continuous domains in real-time. By assigning repulsive force fields to obstacles and an attractive force field to the desired destination, a robot can follow a collision-free path via the computation of a motion vector from the superposed force fields. Especially in the RoboCup domain, there also exist several applications of potential functions for the purposes of situation evaluation and action selection [4–6].

The approach used by B-Smart [7] combines several existing approaches inside a behaviour-based architecture [8] by realising single competing behaviours as potential fields. Such behaviours are e. g. *Move to ball*, *Move to defence position* or *Kick to goal*. The architecture has generic interfaces allowing its application on different platforms for a variety of tasks, e. g. it has already been used by the *German Team* in the Sony Four-legged Robot League [9]. The process of behaviour specification is realised via a generic description language based on XML.

### 4.2 Motion Planning

All motion behaviours are mostly based on the standard motion planning approach by [3]. Some of the main extensions have been the integration of relative motions that allow the robot to behave in spatial relations to other objects, e. g. to organize in multi-robot formations, and the implementation of a path planner to avoid local minima. Figure 2 shows a potential field in the Small Size domain.

Assigning force fields to single objects of the environment allows the avoidance of obstacles and the approach to desired goal positions. Nevertheless, moving to more complex spatial configurations, e. g. positioning between the ball and the penalty area or lining up with several robots to build a defence line is not possible directly. Therefore, a technique, quite similar to [10], has been integrated to map complex spatial configurations to potential fields.

One inherent problem of potential fields are local minima [11]. To avoid situations in which robots get stuck because of defending or narrow positioned opponent robots, all motion behaviours are able to use a real-time path planner. Based on the current gradient of the potential field, it is possible to detect local minima and to use an A* algorithm [12] together with a dynamic search tree, similar to [13].

### 4.3 Action Evaluation

In this architecture, actions are considered to be indivisible entities which have to be executed by the robot after their selection, e. g. the activation of a kick or a predefined dribbling sequence. It is also possible that an action evaluation behaviour is combined with a motion behaviour inside the architecture, the

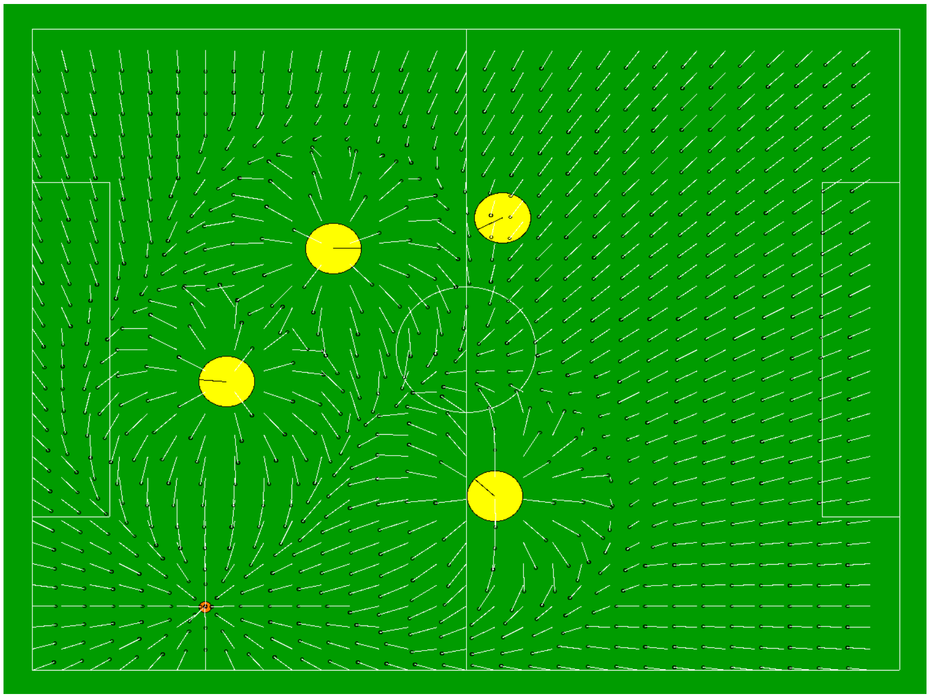


**Fig. 2.** A potential field for moving to the ball and avoiding collisions with other robots. This field is computed by the agent controlling the upper right robot.

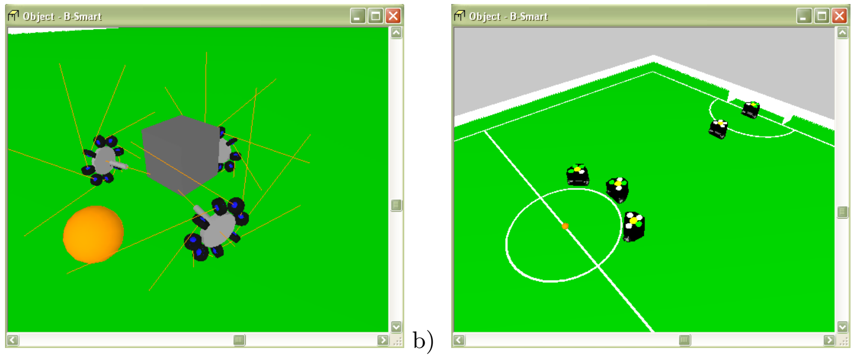
appropriateness of which has to be determined and which has possibly to be executed.

The evaluation is based on the potential functions assigned to the objects in the environment, similar to the approach of [4].

## 5 Using a Simulator

In 2005, the robot simulator *SimRobot* [14] is integrated into the B-Smart software. This simulator has also been used by the German Team in the Sony Four-legged League [9].

The usage of a simulation is a signicifant advantage. On the one hand, it enables the evaluation of different alternatives during the design phase of robot systems and may therefore lead to better decisions and cost savings. On the other hand, it supports the process of software development by providing an ersatz for robots that are currently not on-hand (e. g. broken or used by another person) or not able to endure long running experiments (e. g. learning tasks). Furthermore, the execution of robot programs inside a simulator offers the possibility of directly debugging and testing them.




a) b)

**Fig. 3.** SimRobot simulating B-Smart robots: a) The physical representation of the B-Smart platform. The lines around the wheels denote the axes of the sub-wheels. b) A scene including a Small Size field and five B-Smart robots.

SimRobot is able to simulate rigid body dynamics by using the Open Dynamics Engine [15]. The visualization is completely based on OpenGL.

The physics of the B-Smart robots has been modeled directly, including all details of the onmi-directional drive, as shown in Fig. 3a. This allows a direct simulation of our robot code.

The simulation is integrated in the architecture, which has been described in Sect. 3, by running as a server process which replaces the interfaces of the world modelling and the radio transmission.

## 6 Conclusion and Outlook

During various competitions we have experienced some situations that had a very negative influence on our playing performance, e. g. shadows on the field. To be able to deal with these situations in the future, we are extending our software to be able to deal with dynamic light and shadows conditions. Simplyfied physics support for exact ball and opponent prediction, algorithms for learning and various new behaviours are also under development as to RoboCup 2005. We further want to improve the interaction between our agents and add a new 'coach' agent, that is able to analyse and react to the opponent's tactics.

Besides some short-time hardware extensions with additional sensors, we are already planning our third robot generation, that shall be built for RoboCup 2006 competitions. This new architecture will most likely have four wheels instead of only three, a much stronger kicker and due to the recent rule-changes we will abandon the active dribbling device completely.

The members of the B-Smart team are:

Oliver Birbach, Cornelius Brümmer, Armin Burchardt, Shiyi Chen, Atis Dimants, Carsten Elfers, Ralph Freudrich, Sascha Gerl, Sebastian Huehn, *Jörg Kurlbaum*, *Tim Laue*, Jun Liang, Torsten Moellenbeck, Florian Penquitt, Christian Peper, *Thomas Röfer*, Torben Schindler, Sebastian Schleusener, Hendrik Simon, Kai Stoye, *Ubbo Visser*, Marian Weirich, Haijing Wei, Jie Xu, Jun Zhang

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