

# B-Human

## Team Description for RoboCup 2023

Thomas Röfer<sup>1,2</sup>, Tim Laue<sup>2</sup>, Jo Lienhoop<sup>2</sup>, Ayleen Lührsen<sup>2</sup>, Yannik Meinken<sup>2</sup>, Sina Schreiber<sup>2</sup>

<sup>1</sup> Deutsches Forschungszentrum für Künstliche Intelligenz,  
Cyber-Physical Systems, Enrique-Schmidt-Str. 5, 28359 Bremen, Germany

<sup>2</sup> Universität Bremen, Fachbereich 3 – Mathematik und Informatik,  
Postfach 330 440, 28334 Bremen, Germany

### 1 Team Information

Name: B-Human  
Leaders: Thomas Röfer and Tim Laue  
Contact: b-human@uni-bremen.de  
Website: <https://b-human.de>  
Country: Germany  
Affiliation: Universität Bremen,  
Deutsches Forschungszentrum für Künstliche Intelligenz

#### 1.1 Team Members

**Team Leaders:** Thomas Röfer, Tim Laue

**Students:** Ayleen Lührsen, Enrico Göhrs, Finn Ewers, Florian Scholz, Fynn Böse, Jo Lienhoop, Kelke van Lessen, Laurens Müller-Groh, Laurens Schiefelbein, Lukas Malte Monnerjahn, Michelle Gusev, Sina Schreiber, Yannik Meinken

**PhD Student:** Arne Hasselbring

**Active Alumni:** Jan Fiedler, Philip Reichenberg

### 2 Code Usage

At this point, B-Human is not using code of other SPL teams. As of 2017, we did use the walking engine of rUNSWift, however, through many iterations of ongoing improvements and adaptations, the engine is replaced with our own version by now. In the past, we have drawn inspiration from other teams for our own



Fig. 1: The majority of the current B-Human team members for the RoboCup 2023 season.

software. One example for that would be the cooling of joints as first presented by the SPL team Berlin United. In these cases only the idea was adopted. The implementation was done entirely by us from scratch.

### 3 Own Contribution

#### 3.1 Recent Contributions

During the last three RoboCup years, B-Human published the following scientific contributions:

- *B-Human 2022 – More Team Play with Less Communication* (Champion Paper, to appear in 2023) [13]
- *B-Human 2021 – Playing Soccer Out of the Box* (Champion Paper, 2022) [14]
- *Closing the Reality Gap with Unsupervised Sim-to-Real Image Translation* (2022) [5]
- *Soccer Field Boundary Detection Using Convolutional Neural Networks* (2022) [6]
- *Step Adjustment for a Robust Humanoid Walk* (2022) [9]
- *B-Human 2019 – Complex Team Play Under Natural Lighting Conditions* (Champion Paper, 2019) [12]
- *A JIT Compiler for Neural Network Inference* (2019) [15]
- *JET-Net: Real-Time Object Detection for Mobile Robots* (2019) [8]

Details about our released and maintained software contributions are given in Section 5.

### 3.2 Contributions for RoboCup 2023

Besides maintaining the code from the previous years and adapting it to the rule changes, we aim to develop new features every year to further improve the soccer playing abilities of our robots. Based on observations during the last RoboCup, as well as the upcoming rule changes, we identified the following areas, on which we focus our current research.

We aim to gather a better understanding of the current situation by combining the information from the vision with the team communication and the game state. It is crucial to become less reliant on the team communication that is being progressively limited by the rules. Therefore, we focus on improving our detection of robots in the camera image. As a next step, the identification of the jersey color will be upgraded in order to distinguish more reliably between teammates and opponents.

Many components in our system would benefit from this improved robot detection. For instance, the control of the head motion could be transitioned from static cycles, which only take into account the position of the ball and the walking direction, to a flexible active vision to better observe the action on the field and gather useful information.

This in turn would greatly benefit our new cooperative robot behavior that turned out to be advantageous and increased the performance of B-Human at RoboCup 2022 through passing [13]. Since we expect other teams to develop similar abilities in the future, we are currently developing effective countermeasures, such as marking opponents and intercepting their passes.

Additionally, we are enhancing our motion parts. We aim to improve the walking for worn-out robots, as those tend to walk significantly slower than intended. Moreover, we plan to improve the kicks to reduce deviations in the range and direction. At the same time, we are experimenting with NAOs kicking a rolling ball. This way, a pass could be redirected without stopping the ball, which often causes it to be unintentionally deflected in a chaotic fashion. Furthermore, this ability would allow for immediate goal shots that leave less time for the opponent team to react.

Apart from these adjustments to our robot software, we are also refining the application we developed for last year’s video analysis challenge [1]. In fact, we successfully applied for a league development project funded by the RoboCup Federation to do so.

## 4 Past History

B-Human has participated in the Standard Platform League using the NAO platform since 2009. Since 2019, B-Human has participated in the German Open 2019, RoboCup 2019, GORE 2021, RoboCup 2021, German Open 2022, and RoboCup 2022 and became the overall winner in each of these competitions. Results of the 5v5 soccer competitions are presented in Table 1. Overall, we won the yearly European SPL competitions twelve times and the RoboCup nine times.

Table 1: B-Human’s game results in RoboCup competitions since 2019

(a) German Open 2019			(d) German Open 2022		
Home	Away	Score	Home	Away	Score
<b>B-Human</b>	Berlin United	<b>7:0</b>	RoboEireann	<b>B-Human</b>	<b>0:8</b>
<b>B-Human</b>	Nao Devils	<b>5:0</b>	rUNSWift	<b>B-Human</b>	<b>0:7</b>
<b>B-Human</b>	Bembelbots	<b>7:0</b>	<b>B-Human</b>	HTWK Robots	<b>3:0</b>
<b>B-Human</b>	rUNSWift	<b>5:0</b>	<b>B-Human</b>	Bembelbots	<b>9:0</b>
<b>B-Human</b>	HTWK Robots	<b>4:3</b>	<b>B-Human</b>	Nao Devils	<b>7:0</b>
(b) RoboCup 2019			<b>B-Human</b>	HULKs	<b>10:0</b>
Home	Away	Score	<b>B-Human</b>	Bembelbots	<b>10:0</b>
<b>B-Human</b>	UPennalizers	<b>9:0</b>	<b>B-Human</b>	HTWK Robots	<b>4:0</b>
<b>B-Human</b>	HULKs	<b>5:0</b>	(e) RoboCup 2022		
<b>B-Human</b>	SPQR Team	<b>7:0</b>	Home	Away	Score
<b>B-Human</b>	UT Austin Villa	<b>10:0</b>	Dutch Nao Team	<b>B-Human</b>	<b>0:10</b>
<b>B-Human</b>	Bembelbots	<b>10:0</b>	Nao Devils	<b>B-Human</b>	<b>0:4</b>
<b>B-Human</b>	rUNSWift	<b>3:0</b>	<b>B-Human</b>	HULKs	<b>6:0</b>
<b>B-Human</b>	HTWK Robots	<b>2:1</b>	<b>B-Human</b>	HTWK Robots	<b>8:0</b>
(c) GORE 2021			<b>B-Human</b>	NomadZ	<b>10:0</b>
Home	Away	Score	<b>B-Human</b>	rUNSWift	<b>6:0</b>
<b>B-Human</b>	Nao Devils	<b>10:0</b>	<b>B-Human</b>	HTWK Robots	<b>4:0</b>
<b>B-Human</b>	HTWK Robots	<b>8:0</b>			
<b>B-Human</b>	HULKs	<b>10:0</b>			

We plan to participate in the German Open Replacement Event 2023 in Hamburg, Germany.

## 5 Impact

Since 2009 B-Human has released most of its code each year after the RoboCup [11]. At least 32 teams based their works on our framework or used at least parts of the code we provided. Our GitHub repository [3] currently has 115 forks. Our library for efficient inference of neural networks *CompiledNN* [15] is used by several teams. Our robotics simulator *SimRobot* [7] has been used by others even if they did not use our software framework. We also released our behavior description language *CABSL* [10], which has again been used by others, even if they did not use our base system.

Since 2009 team members of B-Human have published more than 30 reviewed papers directly related to RoboCup, including two that won a best paper award and three that became best paper award finalists.

Since 2012 B-Human has developed and maintained the league’s referee application *GameController*. Over the years, many additional applications were

added, such as the *GameStateVisualizer* and the *TeamCommunicationMonitor*. The *LogAnalyzer* is the basis for game statistics that we have published for each RoboCup and all local European competitions since 2013. To simplify testing our contribution to last year’s video analysis challenge [1], we prepared an easy-to-use index [2] for the GameController logs, the team communication logs, and the game videos of the RoboCups since 2018.

Furthermore, the B-Human team also has a significant educational impact. The majority of the team members are always students who participate in an official project course. For obtaining a degree at the University of Bremen’s computer science department, students have to take such a project course, which is, by the way, heavily weighted in the final grade. We have been running RoboCup-related project courses consistently since the year 2000. Since our start in the current SPL in 2009, more than 140 students participated and learned about many different aspects of robotics. Following the course, many students write their thesis about a B-Human-related topic. To date, 40 theses have been written [4] and a few more are in progress. Many of the aforementioned publications have their origin in one of these theses and build a bridge between education and research.

## 6 Summary

The RoboCup team B-Human is a joint project of the University of Bremen and the German Research Center for Artificial Intelligence, which has been very successful in the past. The team members are constantly working on the codebase, improving it, renewing it, and adapting it to the new conditions based on the rule changes. Our focus this year is on minimizing team communication and improving the robot’s motion sequences. Additionally, the software for the video analysis challenge of the RoboCup 2022 will be further developed. The B-Human team has released a lot of code that is used by others and published several scientific papers over the years. It is also an important educational project at the University of Bremen, in which many students took part over the years.

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