B-Human

Team Description for RoboCup 2026

Thomas Röfer[1,2], Tim Laue[2], Philip Reichenberg[2], Bastian Trimpf[2]

[1] Deutsches Forschungszentrum für Künstliche Intelligenz,
Cyber-Physical Systems, Enrique-Schmidt-Str. 5, 28359 Bremen, Germany
[2] 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: Tom Beuke, Krishnen Ganeshakumar, Steffen Gebhard, Lukas Gittner, Thore Grimm, Jonah Jaeger, Lasse Keller, Leon Koop, Marvin Mantovani, Lukas Malte Monnerjahn, Galin Momchev, Moritz Oppermann, Roman Sablotny, Laurens Schiefelbein, Sina Schreiber, Thade Struckhoff, Bastian Trimpf

PhD Students: Arne Hasselbring, Philip Reichenberg

Active Alumni: Ayleen Lührsen

2 Own Contribution

2.1 Recent Contributions

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

1. *DiDiGen – Dirty Dishes Generator for Randomized Visual Training Data* (to appear in 2026) [5]
2. *Dueling Behavior Leveraging Advanced Motion Control for the NAO Robot* (to appear in 2026) [8]
3. *CABSL 2 – Specification Language for Complex Behaviors* (to appear in 2026) [12]
4. *B-Human 2025 – Towards Referee Understanding and Dynamic Motions* (Champion Paper, to appear in 2026) [15]
5. *Stand Up, NAO! Increasing the Reliability of Stand-Up Motions Through Error Compensation in Position Control* (2025) [6]
6. *Quantized Neural Networks for Ball Detection on the NAO Robot: An Optimized Implementation* (2025) [16]
7. *Automated Game Statistics for the RoboCup Standard Platform League* (2025) [10]
8. *B-Human 2024 – Enhanced Vision and Faster Ball Handling* (Champion Paper, 2025) [9]
9. *Neural Network-based Joint Angle Prediction for the NAO Robot* (2024) [2]
10. *Dynamic Joint Control For A Humanoid Walk* (2024) [7]
11. *B-Human 2023 – Object and Gesture Detection* (Champion Paper, 2024) [14]

2.2 Contributions for RoboCup 2026.

Every year, B-Human makes a variety of changes or new developments in different areas of the code base. This section briefly describes some of our main areas of research and development for 2026.

New Robot Platform. Due to the restructuring of the "Standard Platform League" into the "Humanoid Soccer League", we decided to use this opportunity to switch our main robot platform to the Booster K1 and T1. Thus our main focus this year is on adapting our existing code base to the new robots and also taking advantage of their vastly improved technical capabilities to improve core parts of our system.

Reinforcement Learning. We adapted the reinforcement learning project Booster Gym[3] from Booster Robotics to learn walking, kicking, and getting up for the Booster T1 and Booster K1. We made several smaller changes to reduce differences between the learning environment and the execution on the real robots. We also added workarounds due to bugs or shortcomings of IsaacGym, e. g., floor friction not behaving correctly or collision checks between balls and the robot soles. For kicking, we built a learning environment, in which the robot learns to walk towards and around the ball from any distance and needs to kick the ball towards a given direction with a target velocity. For walking and playing a ball, we reach up to 1.5 $\frac{\text{m}}{\text{s}}$ walking speed and can kick a ball up to 1 m up with a velocity of up to 10 $\frac{\text{m}}{\text{s}}$.

[3] https://github.com/BoosterRobotics/booster_gym

3D Ball Trajectories. Our previous approaches for detecting, tracking, and predicting ball positions and velocities relied on the fact that the ball always remains on the ground floor. However, as aforementioned, the new robot platforms are capable of lifting the ball to significant heights. This is a new situation to deal with, especially for proper goalkeeper reactions. Thus, we plan to be capable of estimating 3D ball trajectories until RoboCup 2026. For the implementation, we can build on preliminary works and experience of our working group, as published in [3] and [1].

3 Past History

B-Human has participated in the Standard Platform League using the NAO platform since 2009. Since 2020, B-Human has participated in the GORE 2021, RoboCup 2021, GORE 2022, RoboCup 2022, GORE 2023, RoboCup 2023, German Open 2024, RoboCup 2024, German Open 2025, and RoboCup 2025 and became the overall winner in each of these competitions. Except for the GORE 2021, which was not an official RoboCup event, these results are all linked on the SPL website. We will participate in the RoboCup German Open 2026 in Köln, Germany.

4 Impact

Since 2009, B-Human has released most of its code each year after the RoboCup [13]. At least 35 teams based their works on our framework or used at least parts of the code we provided. Our GitHub repository[4] currently has 138 forks. Our library for efficient inference of neural networks *CompiledNN* [17] is used by several teams. Our robotics simulator *SimRobot* [4] has been used by others even if they did not use our software framework. We also released our behavior description language *CABSL* [11,12], 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 nearly 40 reviewed papers directly related to RoboCup, including two that won a best paper award and four that became best paper award finalists.

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 heavily weighted in the final grade. We have been running RoboCup-related project courses consistently since the year 2000. Since our start in the SPL in 2009, more than 170 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, 50 theses have been written[5] and a few more

[4] https://github.com/bhuman/BHumanCodeRelease
[5] https://www.b-human.de/theses-en.html

are in progress. Many of the aforementioned publications have their origin in one of these theses and build a bridge between education and research.

5 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 robots and the new league. This year, our focus is mainly on adapting to the new robot platform and the changes to the structure of the league itself. 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.

References

1. Birbach, O., Frese, U., Bäuml, B.: Realtime perception for catching a flying ball with a mobile humanoid. In: Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), Shanghai, China (2011)
2. Fiedler, J., Laue, T.: Neural network-based joint angle prediction for the nao robot. In: Buche, C., Rossi, A., Simões, M., Visser, U. (eds.) RoboCup 2023: Robot World Cup XXVI. Lecture Notes in Artificial Intelligence, vol. 14140. Springer (2024)
3. Laue, T., Birbach, O., Hammer, T., Frese, U.: An entertainment robot for playing interactive ball games. In: Behnke, S., Veloso, M., Visser, A., Xiong, R. (eds.) RoboCup 2013: Robot World Cup XVII. Lecture Notes in Artificial Intelligence, vol. 8371, pp. 171 – 182. Springer (2014)
4. Laue, T., Röfer, T.: SimRobot – development and applications. In: Amor, H.B., Boedecker, J., Obst, O. (eds.) The Universe of RoboCup Simulators – Implementations, Challenges and Strategies for Collaboration. Workshop Proceedings of the International Conference on Simulation, Modeling and Programming for Autonomous Robots (SIMPAR 2008). Venice, Italy (2008)
5. Mach, P., Laue, T., Hasselbring, A., Frese, U.: DiDiGen – dirty dishes generator for randomized visual training data. In: Mascarenhas, A.P.F.M., Ferrein, A.A., Villing, R. (eds.) RoboCup 2025: Robot World Cup XXVIII. Lecture Notes in Artificial Intelligence, Springer (2026), to appear
6. Reichenberg, P., Laue, T.: Stand up, nao! increasing the reliability of stand-up motions through error compensation in position control (2025), https://arxiv.org/abs/2510.02129
7. Reichenberg, P., Röfer, T.: Dynamic joint control for a humanoid walk. In: Buche, C., Rossi, A., Simões, M., Visser, U. (eds.) RoboCup 2023: Robot World Cup XXVI. Lecture Notes in Artificial Intelligence, vol. 14140. Springer (2024)
8. Reichenberg, P., Röfer, T.: Dueling behavior leveraging advanced motion control for the NAO robot. In: Mascarenhas, A.P.F.M., Ferrein, A.A., Villing, R. (eds.) RoboCup 2025: Robot World Cup XXVIII. Lecture Notes in Artificial Intelligence, Springer (2026), to appear

9. Röfer, T., Laue, T., Reichenberg, P., Gittner, L., Schiefelbein, L.: B-Human 2024 – enhanced vision and faster ball handling. In: RoboCup 2024: Robot World Cup XXVII. Lecture Notes in Artificial Intelligence, Springer (2025)
10. Röfer, T., Müller-Groh, L., Hasselbring, A., Laue, T.: Automated game statistics for the RoboCup Standard Platform League. In: RoboCup 2024: Robot World Cup XXVII. Lecture Notes in Artificial Intelligence, Springer (2025)
11. Röfer, T.: CABSL – C-based agent behavior specification language. In: RoboCup 2017: Robot World Cup XXI. Lecture Notes in Artificial Intelligence, vol. 11175, pp. 135–142. Springer (2018)
12. Röfer, T.: CABSL 2 – specification language for complex behaviors. In: Mascarenhas, A.P.F.M., Ferrein, A.A., Villing, R. (eds.) RoboCup 2025: Robot World Cup XXVIII. Lecture Notes in Artificial Intelligence, Springer (2026), to appear
13. Röfer, T., Laue, T.: On B-Human's code releases in the Standard Platform League – software architecture and impact. In: Behnke, S., Veloso, M., Visser, A., Xiong, R. (eds.) RoboCup 2013: Robot World Cup XVII. Lecture Notes in Artificial Intelligence, vol. 8371, pp. 648–655. Springer (2014)
14. Röfer, T., Laue, T., Hasselbring, A., Böse, F., Monnerjahn, L.M., van Lessen, K.: B-Human 2023 – object and gesture detection. In: Buche, C., Rossi, A., Simões, M., Visser, U. (eds.) RoboCup 2023: Robot World Cup XXVI. Lecture Notes in Artificial Intelligence, vol. 14140. Springer (2024)
15. Röfer, T., Laue, T., Reichenberg, P., Gittner, L., Oppermann, M., Sablotny, R.: B-Human 2025 – towards referee understanding and dynamic motions. In: Mascarenhas, A.P.F.M., Ferrein, A.A., Villing, R. (eds.) RoboCup 2025: Robot World Cup XXVIII. Lecture Notes in Artificial Intelligence, Springer (2026), to appear
16. Thielke, F.: Quantized neural networks for ball detection on the NAO robot: An optimized implementation. In: RoboCup 2024: Robot World Cup XXVII. Lecture Notes in Artificial Intelligence, Springer (to appear)
17. Thielke, F., Hasselbring, A.: A JIT compiler for neural network inference. In: Chalup, S., Niemueller, T., Suthakorn, J., Williams, M.A. (eds.) RoboCup 2019: Robot World Cup XXIII. Lecture Notes in Artificial Intelligence, vol. 11531, pp. 448–456. Springer (2019)