Berlin United – Team Description Paper 2026

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Team Berlin United at the RoboCup 2025 in Salvador, Brazil. From left to right: Anastasia Prisacaru, Heinrich Mellmann, Magdalena Yordanova, Anton Gerstenhoefer, Stella Alice Schlotter, Philipp Strobel, Zhuo Liu.

The research group *Berlin United* (BU) is part of the research lab for Adaptive Systems at the Humboldt-Universität zu Berlin (HU). The team consists of students and researchers at different career stages, including Bachelor, Master/Diploma, PhD, Postdoctoral researchers, as well as active alumni. Berlin United has successfully participated in nearly all RoboCup Standard Platform League (SPL) competitions since the first SPL tournament in 2008, contributing both to competition performance and to scientific progress in humanoid robotics. Our research interests span a broad range of topics in cognitive and embodied robotics, including modular software architectures, bipedal locomotion, multimodal perception, behavior generation, simulation, as well as the development of tools and datasets. Our contributions are regularly published, and our code, datasets, and scientific publications are made publicly available on our website. In addition to research and direct participation in RoboCup competitions, Berlin United is actively involved and contributes to university teaching, public outreach and scientific communication, and the continued development of the RoboCup community.

1 Research Focus and Contributions

Our main focus for the RoboCup 2026 is the generalization and adaptation of our code base to the conditions of the new Humanoid Soccer League (HSL). We are also currently working on adapting our code to work with the robots Booster K1 and plan to complete the adaptation for the RoboCup 2026. In this section, we highlight a few noteworthy contributions and ongoing projects that are relevant for the RoboCup 2026. Examples of other noteworthy contributions from recent years that resulted in scientific publications, theses, and concrete implementations include [22,13,25,27,12,14,24,15,21,23,26].

Behavior For individual decisions, our robots use internal simulation to predict the outcome of different actions and to make decisions in highly complex and uncertain situations. For example, the robots predict the ball's behavior (e.g., the movement of the ball and its collision with obstacles) for different possible actions (e.g., kicks) and choose the action promising the best outcome. The decisions can be adapted easily to new actions by adding the appropriate internal simulator. This allows us to rapidly adapt the approach to the action primitives of the new robot platform Booster K1. This approach has been used in RoboCup SPL games and continuously studied and extended since 2015 [19,18,20,16,17].

For team coordination, our robots employ a highly dynamic team strategy, including role negotiations between players and assignment of locations on the field. The role assignments depend on the importance of the roles and the situation in the field. The parameters for the team strategy were optimized based on a large number of simulated SPL games, which were transferred and successfully used in real RoboCup games [26]. For this, we adapted the official physical simulator *SimSpark* of the Simulation 3D League (S3D) to the SPL [6].

The gradual limitations in team communication in the past years led to delays and to a significant reduction in accuracy in role negotiations. To approach this challenge, we plan to extend the simulation-based decision approach described above. A robot can make a role decision by simulating and predicting the actions of other players, which reduces the necessity of the explicit communication. The theoretical work and initial experiments show promising results. We plan to employ a first version at the RoboCup 2026. We also consider the adaptation of the new simulator of the S3D SimSparkMJ [7] to the HSL.

Perception Our vision system is optimized for robots with limited computational resources and is based on a combination of sparse heuristic processing (e.g., key point detection) and highly optimized neural networks (e.g., object classification). We continuously experiment with different approaches, such as Variational Autoencoders (VAE) [22]. To experiment and to train the networks, we build a flexible training pipeline [25]. The pipeline is continuously being improved. We are now able to automatically annotate images from logs and immediately use them for training for the next game. Our system makes it easy to include only the data we want. For example, we can easily filter for robots, time of day, field, and event. Currently, we are working on a new efficient ball detection for the new ball in the HSL small division for the NAO robots.

Motion and Behavior Primitives Our motion engine allows for seamless integration of dynamic and parameterizable in-walk kicks [13]. For RoboCup 2026 we are developing a range of new kick actions that would allow the robot NAO to effectively handle the new larger ball in the HSL small division. We are also working on a Reinforcement Learning (RL) approach for motion and behavior primitives for the robot Booster K1. We have trained a policy realizing a combined behavior able to approach and kick the ball in simulation. We plan to transfer this strategy to the real robot and use it at the RoboCup 2026.

Data Driven Research in RoboCup Collecting rich, well-structured data from RoboCup games on a large scale can help us study and develop new approaches and to track league progress, advancing the league and RoboCup as a whole. To approach this, we have developed a system to record and analyze synchronized RoboCup data including game videos and robot logs on a large scale. We deployed the recording system at the RoboCup competitions since 2019 and collected numerous synchronized videos of games on all fields. The collected data and more information on that project can be found on the project website [1]. Our project gained significant recognition – was supported through several RoboCup Federation Research Grants, cited in the landmark publication [11], became a part of the official SPL league development strategy and was used as a basis for the Open Challenge at the RoboCup 2022 [8,3]. We continue upgrading the system and are also working on an integration of streaming and recording of RoboCup games in collaboration with the team *Nao Devils*.

2 Impact and Other Contributions

Our team is actively and continuously contributing to the RoboCup community. In the following, we outline a few highlights.

Scientific Communication and RoboCup Organization We organize and actively contribute to various public and non-public RoboCup events, like RoHOW, Rodeo, *Long Night of Science* in Berlin [10], *Berlin Radio Show* [9], and many more. We regularly publish at the RoboCup Symposium. The members of our team are actively involved in organizing official RoboCup events as OC, TC, and Local League Chairs.

Impact on Our University and Community RoboCup is a great opportunity for our students to connect with other students and researchers on an international level. RoboCup provides strong motivation to work on robotic problems and attracts a significant number of students. Our team is actively participating in teaching activities at our university. We supervise thesis projects at all academic levels and offer classes focused on current RoboCup topics each semester. Our team is well known in the University and local campus and is often invited to local public events and interviews.

RoboCup 1998 – 2026 The team *Berlin United* (BU) was founded at the end of 2007 under the name *Nao Team Humboldt* (NaoTH) at the lab for Artificial Intelligence at the Humboldt-Universität zu Berlin. *NaoTH* was founded as a

direct successor of the *Aibo Team Humboldt*, which was active in the *Four-Legged League* of the RoboCup as a part of the *GermanTeam* from 1998 until 2008. *NaoTH* has been a member of the SPL from the first SPL competition in 2008 in Suzhou, China, until the last competition in 2025 in Salvador, Brazil. In that time, we successfully and actively participated in nearly every RoboCup and German Open, as well as numerous other international and local competitions. In 2026, our team is officially joining the newly formed *Humanoid Soccer League* (HSL) and intends to compete in the *small* and *middle* divisions.

Bridging the Community – SPL, HL and S3D In addition to our main focus on SPL, our team invested significant energy in bridging between the SPL, the Humanoid League, and the Simulation 3D League.

- *Bridging SPL and HL:* In 2011, we formed a conjoint team *Berlin United* with the team *FUmanoids* from Berlin, which participated in the Humanoid KidSize League. In 2017, the team *FUmanoids* ceased to exist, and we continue to compete under the name *Berlin United*. The collaboration included extensive exchange of experience, development of a joint code base, joint games, and joint workshops. In this time, we actively contributed to narrowing the gap between the leagues, for example, to unifying the field dimensions. Throughout years 2011 – 2013, we organized a series of workshops known as *RoboCup Berlin Open Workshop* (*RoBOW*) for teams from SPL and HL [4]. *RoBOW* grew into a regular series of RoboCup workshops organized by different universities, most notably *RoHOW*, organized by the team *HULKs* [5] in Hamburg/Germany, and *Rodeo* [2], organized by the team *Nao Devils* in Dortmund/Germany.

- *Bridging SPL and S3D:* In 2010 and 2011, we competed in the 3D Simulation League (S3D) using the same code as for the SPL. We won the German Open and the AutCup competitions, and achieved *2nd place* at the RoboCup World Championship 2010 in Singapore, only narrowly losing the final match in overtime. We also extended and adapted the official physical simulator *SimSpark* of the S3D to be used within the SPL and made it available to the community [6]. The simulator won 1st place in the Open Technical Challenge in the SPL at the RoboCup World Championship 2012 in Mexico.

- *Bridging Within the SPL:* We successfully competed at the SPL Mixed Team Competition. In 2017 and 2018, we achieved 2nd place as a joint team *DoBerMan* together with the team NaoDevils. In 2019, we won 1st place as part of the mixed team *B&B* together with *B-Human*.

Selected Recent Results In 2019, we won all SPL Technical Challenges and the Mixed Team Competition as part of the Mixed Team B&B together with B-Human. During the COVID pandemic, in 2021, our team achieved 3rd place in the *Obstacle Avoidance Challenge*. After a break in 2022 caused by the pandemic, our team began its recovery and successfully participated at the RoboCup in Bordeaux in 2023. At the competitions in 2024 and 2025, our team continuously and significantly improved our global Glico-Rating, reaching 6th place in the overall ranking (quarter-finals) after narrowly losing the quarter-finals in the last 20 seconds of the game at the RoboCup 2025 in Salvador, Brasil.

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