FBOT@Home CBR 2025 RoboCup@Home Team Description Paper

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***Abstract*—The following Team Description Paper (TDP) describes the FBOT@Home team and its Brazilian Open Robot for Indoor Service (BORIS), created by members of the NAUTEC group at the Federal University of Rio Grande (FURG), Brazil. This document also describes the team's customized mechanical designs and public contributions provided to the league, in the form of code packages developed by our team, such as vision, speech, behavior, world, simulation, and more. All developed modules are open source and are available at: https://github.com/fbotathome.**

***Index Terms*—RoboCup Brazil, BORIS, Animatronic Face, DIY Mobile Base.**

I. Introduction

As the demand for intelligent and autonomous systems continues to grow, our team is dedicated to pushing the boundaries of what domestic robots can achieve, striving to continue making developments in robotics and automation. This paper presents a comprehensive description of our work, highlighting our recent research and the changes made to further progress in domestic robotics.

During the past year, our team has undergone multiple transitions, switching in 2024 from our established domestic robot, DoRIS, to a brand new and more modular model, the Brazilian Open Robot for Indoor Service (BORIS). Furthermore, in 2025, we have fully made the transition to ROS2, completely porting our old software to better integrate with modern robotics tools and libraries.

BORIS, shown in Fig. 1, is a service robot consisting of a mobile platform, a torso with processing units, an animatronic face and a 5-DoF manipulator. The FBOT@Home team, previously known as BUTIABots, is part of the NAUTEC research group. The group's goal is to research and develop robotics and automation solutions applied to real world problems.

With our previous robot DoRIS and our new robot BORIS (since RoboCup Eindhoven 2024), the FBOT@Home team has already participated in several RoboCup@Home competitions, securing notable achievements.

- 3rd Place: Brazilian Robotics Competition 2018 - 2020 (RoboCup Brazil);
- 2nd Place: Brazilian Robotics Competition 2021 (RoboCup Brazil);
- 3rd Place: RoboCup Bangkok 2022;
- 1st Place: Brazilian Robotics Competition 2022 (RoboCup Brazil);

Fig. 1: BORIS' mechanical construction.

- 9th Place: RoboCup Bordeaux 2023;
- 1st Place: Brazilian Robotics Competition 2023 (RoboCup Brazil);
- 11th Place: RoboCup Eindhoven 2024;
- 1st Place: Brazilian Robotics Competition 2024 (RoboCup Brazil).
- 7th Place: RoboCup Salvador 2025;

To introduce the focus of our team, this document is organized as follows: Sec. II presents our research, Sec. III presents our contributions to the league, and Sec. IV presents the conclusion.

II. Research

The team maintains a strong commitment to research, constantly exploring new methods and edge technologies to push the boundaries of robotics and automation, while also improving the knowledge and abilities of our members.

A. Manipulation

In the previous version, with DoRIS, our team had developed a custom robotic arm. However, this arm caused numerous issues due to inaccuracies in the UDRF system, making it difficult to achieve high precision with its DIY components. Additionally, the deprecated Dynamixel servo-actuators used were outdated, lacked support, and had worn out, leading to movement loss. Consequently, with all the changes implemented for BORIS, the manipulation unit was also updated to the 5-DoF Interbotix WidowX-200 Robot Arm, which was relocated from an Interbotix LoCoBot.

One of the disadvantages encountered with the WidowX-200 was the limited opening range of the gripper, which was not sufficient to grab larger objects required in competition tasks. In order to solve this problem, it was decided to upgrade to a new gripper, 3D printed in PLA, with a scissor-like motion. This gripper was specifically designed to optimize both dimensions (width and range) and movement precision.

Another challenge that we have been facing is the gripper's weight limitation, as the WX-200 Robot Arm only supports a maximum working payload of 200 grams due to the servo's torque. To address this, a new upgrade is being formulated to accommodate the potential requirement of lifting heavier items in competitions.

We employ the Interbotix ROS Toolboxes[1] package, to enable the robot to perform arm movements in any Cartesian direction, unrestricted by specific axes. Furthermore, our system incorporates the MoveIt[2] framework with OMPL[3] for motion planning. The integration of these tools ensures optimal arm movement, allowing the robot to use the most suitable tool for each specific situation.

Lately, our team has dedicated efforts to improve the safety of manipulation tasks. Leveraging our computer vision packages, we can precisely identify the midpoint of objects. This capability allows the robot arm to grasp items near their bases, ensuring secure handling. Upon release, the gripper can safely deposit the item on a flat surface, mitigating the risk of accidental falls.

B. Person Re-Identification

The task of following a specific person presents numerous challenges when done by a robot. When using a computer vision pipeline, first, it must identify the person to be followed, then acquire the position of the individual in the world, remove outliers, and ensure navigation while maintaining a safe distance without falling behind.

Our approach used to utilize object tracking, which is based on the person bounding box movement. In the case of the person being out of frame for a few seconds or under complete occlusion, the tracking is lost, and if they go back into frame, the robot does not understand whether it is the same person or not. To solve this problem, a re-identification method was implemented, in which the image patch of the person is used as an input to a neural network, to extract the features of that person.

The re-identification checks whether or not the bounding boxes are similar enough to be considered the right person within the available set. This is done by comparing the distance of the features of current people identified in the frame with those already stored. In order to avoid interference from external noise, such as brightness variance, new features are supplied to the re-identification method whenever the tracking successfully identifies the correct bounding box and the features differ beyond a threshold.

C. Hot swap battery system

To ensure uninterrupted operation, we developed a hot swap battery system, which allows battery replacements without shutting down the robot. The robot uses four 36V battery packs, repurposed from self-balancing scooters, with replacements performed two at a time to maintain power stability when newly charged batteries were connected alongside partially discharged ones.

To address voltage imbalances, high-power diodes were added to each battery pack, isolating them from each other. This configuration, detailed in Fig. 2 ensures that current flows only from each battery to the system's devices, preventing backflow into other batteries. In addition, LEDs were installed on each battery pack to confirm the proper connection, reducing the risk of misalignment or incomplete connections.

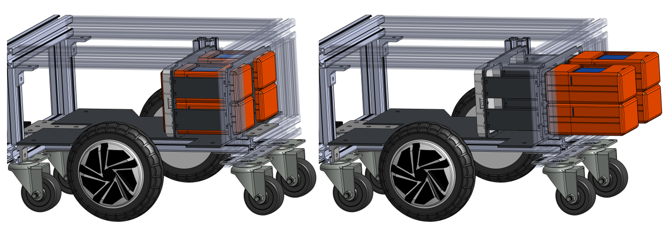


Fig. 2: Hot swap battery system.

D. Enhancing Human-Robot Interaction Through Speech AI

In our pursuit of improving human-robot interactions, we have prioritized advancements in speech-to-text (STT) and text-to-speech (TTS) systems. Although these critical technologies are critical for effective communication, they presented significant challenges since we observed slow processing times which limited real-time interaction and the STT system struggled with accurate transcription, especially in noisy environments or in complex sentences. Furthermore, the robotic quality of the TTS voice reduced the system's conversational appeal. To address these deficiencies, we adopted cutting-edge solutions tailored to enhance our robot's speech capabilities:

1) **Text-to-Speech (TTS):** We implemented the NVIDIA Riva library[4], renowned for its ability to produce high-

[1] GitHub Repository: https://github.com/Interbotix/interbotix_ros_toolboxes

[2] Official Website: https://moveit.ros.org/

[3] Official Website: https://ompl.kavrakilab.org/

[4] GitHub Repository: https://github.com/nvidia-riva

quality, human-like voice output. Riva delivers exceptional speech generation at remarkable speeds, enabling the robot to respond almost instantaneously during conversations. The dynamic and expressive tone enhances the robot's interaction abilities, making communication more engaging.

2) **Speech-to-Text (STT):** For accurate and fast transcription, we incorporated the open-source RealtimeSTT library[5]. Its robust speech pipeline includes Voice Activity Detection (VAD) to efficiently detect when a speaker starts or stops talking, which reduces the processing load, and using Faster Whisper, it delivers quick and reliable transcription, even for diverse accents and challenging scenarios.
3) **Hardware Upgrades:** To support these advanced technologies, the robot's processing capabilities were significantly enhanced with the NVIDIA Jetson AGX Orin (64GB). This upgrade provides the computational power necessary to handle intensive AI workloads, including real-time STT, TTS, and other complex speech-related tasks.

These improvements have dramatically reduced processing delays, improved transcription accuracy, and elevated the overall interaction quality. The robot now performs effectively in various environments, seamlessly adapting to different accents and background noise levels.

Looking ahead, our team aims to refine these systems further by exploring emotion-conditioned speech synthesis, multi-language support, and incorporating adaptive learning to improve STT accuracy over time through user interactions.

E. Dataset Collection Strategies for Robotic Manipulation

Robotic manipulation is a central focus of research in our team, as it represents a major challenge in both RoboCup and the Brazilian Robotics Competition (CBR). As our team began advancing its manipulation capabilities, we recognized the importance of exploring effective dataset collection strategies, especially those that support modern learning-based approaches such as Imitation Learning (IL) and Reinforcement Learning (RL).

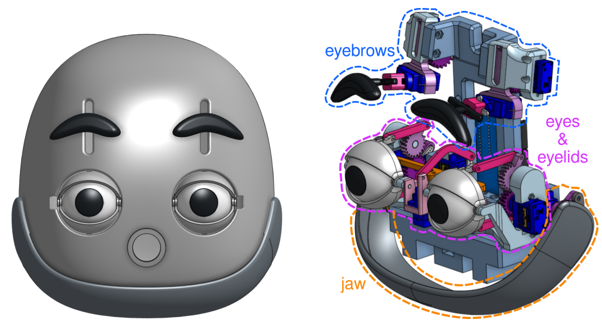
In contrast to areas like computer vision or natural language processing, where large datasets can be easily sourced online, robotics faces a scarcity of high-quality, diverse data. This challenge is particularly relevant to learning-based manipulation, where generalization across tasks and environments is only possible with large and scalable datasets. Our research is grounded on recent developments in the field, including collaborative dataset collection efforts [6], [9], simulation-augmented methods [7], and low-barrier interfaces such as manual grippers [2], [4].

This topic was explored in our recent publication [3], which was presented at the RoboCup Symposium 2025. The paper reviews methods and challenges in data-driven manipulation and contributes to the ongoing discussion on how to enable more scalable and transferable learning in robotic systems.

[5]GitHub Repository: https://github.com/KoljaB/RealtimeSTT

F. Human-Robot Interaction through facial expressions

One of the highlights of this robot design is its electromechanical 3D printed animatronic face, Fig. 3. In the @Home League context, it is expected for service robots to operate in residential environments and in proximity to non-experienced individuals. For this matter, these robots should display enough sympathy to avoid causing discomfort to users.



(a) External design (b) Internal systems

Fig. 3: BORIS'face

This feature is an ongoing developmental project that has evolved beyond the scope of the robot itself, being part of a social behavior study. Our review of animatronic faces [10] focusing on social robotics was recently published at the 2025 Brazilian Conference on Robotics (CROS). The paper analyzes how different anthropomorphic robotic interfaces designs impact HRI acceptance. The review emphasizes the models mechanical systems, and interactive potential of robotic faces in social environments.

Further on, we have an ongoing study on human-robot interaction as part of a master's project. The objective of this research is to improve human-robot interaction, by assessing individuals' responses to the animatronic and chattering face of BORIS.

G. Object Detection using Moondream

To eliminate the need for annotating images and training new weights for YOLO models with the specific objects of each competition, an alternative strategy is being explored for object detection purposes, using Moondream2 [12].

Moondream is a compact Vision-Language Model (VLM) that is capable of performing a variety of image-understanding tasks using simple natural language prompts. For our application, it is especially useful because it can run locally without requiring substantial computational resources.

The task we address is object detection: given the name or description of the object of interest, the VLM processes the input and returns the bounding boxes of the objects found in the frame. These bounding boxes are then used to estimate the objects' positions in the real world for subsequent interactions. This approach opens new avenues for robotic perception and contributes to a modular and plug-and-play architecture for robotic systems.

H. Digital environment description and reconstruction using panoptic segmentation

We present a novel digitalization pipeline using panoptic segmentation to achieve faithful digital representations of real-world environments. Our pipeline employs posed images from a given scene and a method based on DM-NeRF for segmentation and reconstruction of the environment with no prior object detection or segmentation. The resulting three-dimensional meshes are then converted into XML files, categorized according to their panoptic classification, to produce an SDF file compatible with simulation software. A description of the proposed method can be seen in Fig. 4.

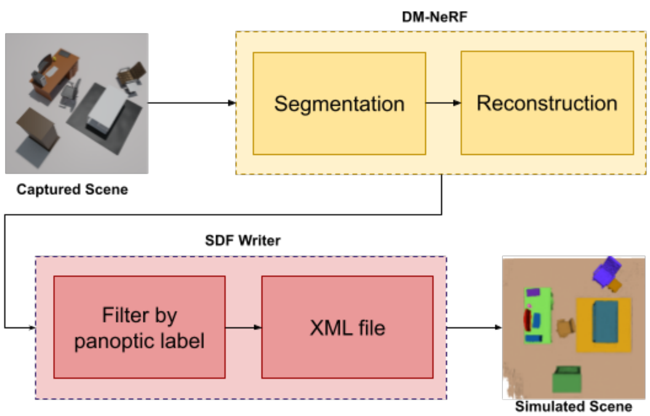


Fig. 4: The proposed pipeline: All individual objects are segmented and reconstructed with the appropriate labels, then transformed into the required format for simulation.

Quantitative evaluations of the scene reconstruction and segmentation processes yielded results with high fidelity and minimal noise. The pipeline was validated on the DM-SR dataset, which features eight typical household rooms. Our method produces accurate digital renditions of real-world environments and integrates them into the Gazebo simulation platform. This fact enables robots to navigate and interact within the virtual scene, allowing system validation without the risks and costs associated with real-world experiments.

One of the applications for these features is the Robocup@Home competition, where the limited time allotted for each team in the arena makes creating a simulated environment both challenging and valuable, while the controlled nature of the environment serves as an ideal setting. Using the described method, posed images of the arena can be captured to quickly generate a simulated version of all objects in the scene.

I. Agentic LLM Architecture for General Purpose Service Robots

In order to execute the General Purpose Service Robot task of the RoboCup@Home Competition, we propose an agent-based architecture built on top of the open-source SmolAgents [11] library. The architecture is composed of a multimodal language model, such as Gemini or Qwen2.5-VL, a set of tools wrapping low-level behaviors, such as *pick*, *place* and *navigate*, and a Python code interpreter. The agent uses Chain-of-Thought prompting to reason about its next actions, given previous actions and current camera observations as context. The agent then writes Python code for chaining the tools and executes the program in the code interpreter.

III. Contributions

The team has made significant contributions to the field of robotics through research, development, and the organization of events aimed at fostering and inspiring the study of robotics. Notable inclusions are the involvement our team had organizing the Brazilian Robotics Competition (CBR) in 2019, which was hosted at FURG, open source code and tutorials on Github, as well as the representation on the technical committee of the Brazilian league through one of the team's members.

A. Re-usability

All ROS packages developed for our robot are open source and available on Github (https://github.com/fbotathome), complete with comprehensive documentation. Through our FBOT Learning repository, we aim to provide a range of tutorials that cover the utilization of various systems commonly employed in domestic robotics. The primary objective of this initiative is to facilitate the training of new members of our team and improve the dissemination of information between RoboCup teams.

Our packages include all the research described in the previous section. In particular, a significant portion of these packages can be adapted to development platforms beyond BORIS, rendering them valuable for a diverse range of applications with ROS and ROS2.

B. ROS2 & YASMIN

With ROS1 reaching its end-of-life in May 2025, our team has initiated the transition to ROS2 Humble. The ROS2 ecosystem offers packages such as Nav2, MoveIt2, and SLAM Toolbox. As our previous state machine library, SMACH, has not kept pace with ROS2 development, we replaced it with YASMIN (Yet Another State MachINe) [5].

During this transition, several team members actively contributed to the development of YASMIN, as it is an open source project in Github[6]. Contributions from our team included the addition of global blackboard variable remapping, new default outcomes, demonstration files, and support for parameterized callback states, allowing for the passing of both positional and keyword arguments to user-defined state functions.

[6]Github Repository: https://github.com/uleroboticsgroup/yasmin

C. Virtual Environment using Gazebo

A significant bottleneck in robotics development is the reliance on physical hardware for testing, since access to the robot is often limited, it can be time consuming, and there is a constant risk of damaging expensive components when performing tests. To overcome these challenges, our team developed a high-fidelity simulation environment in Gazebo as shown in Fig. 5, creating a virtual testing ground that mirrors the real-world conditions of the 2024 Brazilian Robotics Competition arena.

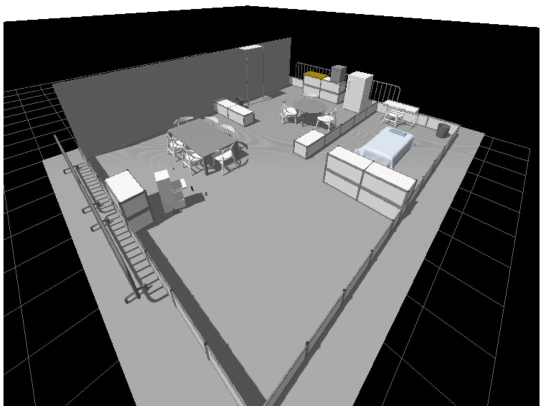


Fig. 5: Gazebo simulated environment.

The use of this simulation provided significant advantages for our internal development process. It contributes to accelerate development progress by enabling parallel workflows, where multiple members can simultaneously test code for navigation, perception, and manipulation while pushing the robot to its limits without the risk of damaging the hardware.

We have made this project completely open-source and the entire simulation environment, including all arena models and world files, is publicly available on our team's GitHub repository (https://github.com/fbotathome). We are currently focused on improving the documentation to streamline the on-boarding process for our new team members and facilitate adoption by other teams in the community.

D. Open-source and open-hardware mobile base for service robotics

The Stable Hoverboard-driven Autonomous Robot Kit (SHARK) aims to advance the development of service robotics in Latin America by offering a cost-effective solution for mobile platforms, thereby enabling emerging researchers to begin their work in this field [1].

To achieve this, we repurposed the components of self-balancing scooters, commonly called hoverboards. This process involved modifying the firmware on the device's motherboard, allowing communication with the Robot Operating System (ROS). This approach significantly reduces costs, maintains system reliability, and leveraging well-established, robust components. The mechanical design, shown in Fig. 6, is based on readily accessible hardware, such as square cross section extruded aluminum bars, industrial caster wheels, springs, and other structural units, all widely available on the market.

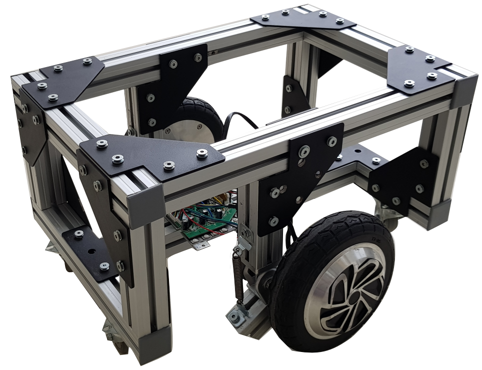


Fig. 6: SHARK mobile base.

In October 2023, supported by the RoboCup Federation, the team organized a workshop at the Latin American Robotics Symposium (LARS). The objective was to showcase our mobile base and offer comprehensive instructions to attendees on how to build a similar or modified platform.

Following the workshop, the mobile base was further tested in different competitions, earning the 11th place at RoboCup Eindhoven, the 1st place at CBR 2024 and the 7th place at RoboCup Salvador, proving to be a stable low-cost solution.

The platform has attracted significant interest and adoption from other teams, particularly those whose members attended the 2023 workshop. The UTBots team developed their own version of the SHARK mobile base and competed with it at both the Brazilian Robotics Competition and RoboCup Salvador [1].

Beyond competitions, the platform has also been adopted in educational and research contexts [8], with several projects at different universities adapting the system for diverse applications.

IV. Conclusion

This paper outlines the approaches used by the FBOT@Home team to create an intelligent system for home service robots, while presenting our robot BORIS. Our discussion covered our architecture for general purpose tasks, as well as our new hot swap battery system developed for the SHARK base and our contributions to ROS2 packages.

Moreover, our research focused on dataset collecting methods for manipulation, a person re-identification method for smoother following, animatronic faces, as well as a low-cost, high-capacity, and open-source mobile base developed with the aim of fostering advancements in home robotics, particularly in the context of Latin America.

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