RoboCup Brazil TDP – UnipDroidians@Home

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Abstract* — *This paper presents an overview of the robot developed by the UnipDroidians team for participation in the RoboCup @Home competition. As this marks the team's first year in the competition, we describe the systems that were developed and integrated into the robot, including its structure, locomotion, mapping, object recognition, centralized processing, human–machine interface (HMI), and manipulator arms.

Index Terms* — *RoboCup Brazil, Service Robot, @Home.

I. Overview

The proposed robot for the competition features two manipulator arms mounted on an aluminum profile structure, with a differential drive wheel system, thus configuring a mobile autonomous robot designed to perform household tasks.

The system is composed of multiple subsystems, integrated into modules as presented in Figure I.1.

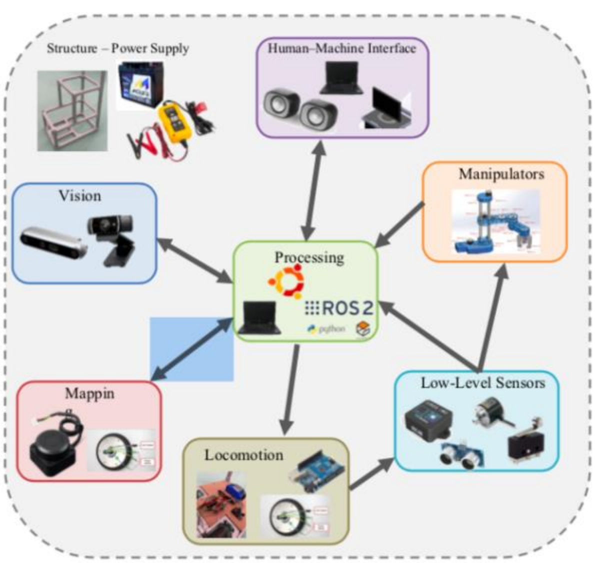


Figure I.1 –System Architecture

For the development of this prototype (team founded in 2025), members worked primarily on specific subsystems as well as integration. Table I.1 presents the team members and their main responsibilities.

Table I.1 – Team Members

Name:	Luis Fernando Assunção dos Santos Silva
Function:	**Captain / Integration**
Name:	William Pinto Penco
Function:	**Navigation / SLAM**
Name:	Julia Meneses Roberto
Function:	**Sensors and Power**
Name:	Ramon Kainã Ferreira dos Santos
Function:	**IHM/ Processing**
Name:	Leonardo J. G. Miranda Siqueira
Function:	**Manipulators**
Name:	Luccas Bueno Sarai
Function:	**Motors**

The robot modules are equipped with:

- **Sensors:** LIDAR (RPLIDAR C1 Slamtec), cameras (RealSense D457), IMU, webcam and microphones, proximity sensors.
- **Actuators:** Brushless differential drive hoverboard motors (8-inch, 36V), two robotic arms with custom kinematic models, two-finger gripper with adaptive adjustment.
- **Onboard computing and processing:** Dell notebook, NVIDIA Jetson Xavier board, Arduino UNO.
- **Operating system:** Ubuntu + ROS Humble.
- **Frameworks and libraries:** ROS, OpenCV, PCL, TensorFlow/PyTorch, Navigation2, etc.

This prototype represents the team's initial development for the current participation. As such, it does not introduce innovations relative to a previous version. Nevertheless, based on the research conducted and the proposed approaches, noteworthy aspects include the selection of the locomotion systems and the implementation of two robotic arms.

A. Innovation

1) Mechanical and Electrical:

- **Motor and Wheel Enhancements:** Motor and Wheel Enhancements: Brushless hoverboard motor with 8-inch solid tire (36V), powered by a dedicated 36V battery and controlled by a RioRand ZS-X11H motor controller.

2) Robotic arms:

- **Two 6-DoF arms:** with configuration similar to SCARA robots, each equipped with adaptive two-finger grippers.

II. SYSTEM ARCHITECTURE

The system follows a modular ROS-based architecture, with communication through topics for integrating sensors, motion planning, actuator control, and human–robot interaction. Figure II.1 shows the digital assembly of the robot.

Figure II.1 – Robot Model in a Digital Environment.

The main modules and their functions include:

- **Perception and Vision:** Image processing, object detection and recognition.
- **Navigation and Localization:** SLAM with Gmapping and slam_toolbox, environment mapping, path planning, and obstacle avoidance using Navigation2.
- **Manipulation:** Robotic arm control, object grasping, and force control for delicate manipulation.
- **Human–Robot Interaction:** Speech recognition with ros_voice_control and Google Speech API, speech synthesis with Festival, and chatbot-based dialogue models.

For the development, the following algorithms and libraries were employed:

A. Perception and Computer Vision

- Object detection and classification using convolutional neural networks (YOLO).
- Scene segmentation.
- Facial recognition using [FaceNet].
- Sensor fusion involving LIDAR, odometry, and camera data for mapping.

B. Navigation and Localization

- SLAM using <slam_toolbox>, integrated with LIDAR and visual odometry. (Figure II.2)
- Path planning.
- Strategies for avoiding dynamic obstacles, using Navigation2.

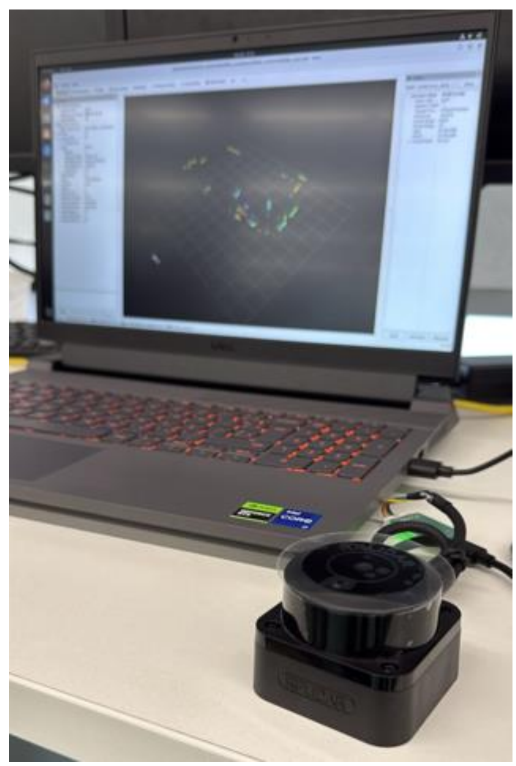


Figure II.2 – Mapping Using RPLIDAR and the Computer Employed.

C. Manipulation

- Robotic arm control via ROS with a kinematic model.
- Object grasp planning.
- Force control for delicate manipulation using a proportional gripper and adaptive fingers.

D. Human-Robot Interaction

- Speech recognition using [<ros_voice_control> and <Google Speech API>].
- Speech synthesis using [Festival].
- Dialogue modeling based on a [chatbot].
- Behaviors and command execution using [ros2_behavior_tree].

III. Mechanical and Electrical System

The robot’s mechanical structure was built using 30x30 aluminum profiles, divided into multiple platforms to accommodate embedded devices:

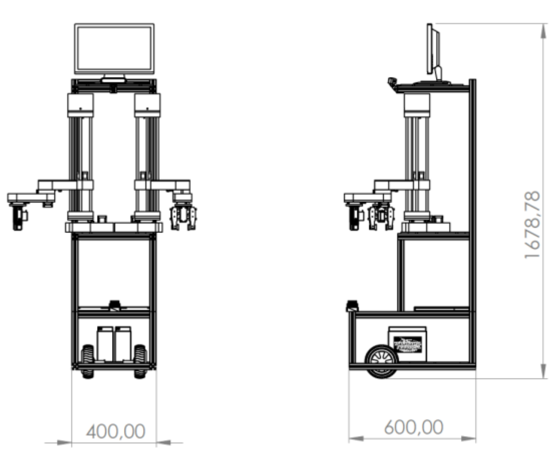
i) Motors, drivers, batteries, and odometry sensors.

ii) Central computer, communication boards, wiring hub, frontal support platform for objects, and LIDAR mount.

iii) Mounting base for robotic arms.

iv) Elevated base for HMI screen and RealSense camera.

This year, the main objective was the construction of the robotic platform so that in the coming years it can be improved and its functionalities — currently basic for competition participation — can evolve. Drawings of the robot's views, as well as an image of the actual structure, are presented in Figures III.1 and III.2 below, showing the partial assembly of the prototype in a real environment.



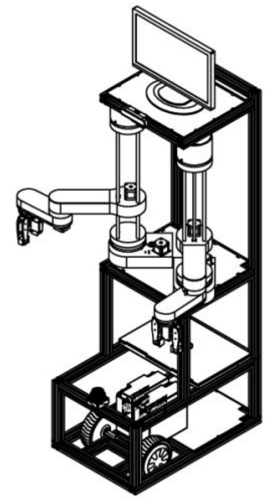


Figure III.1 – Views of the Robot

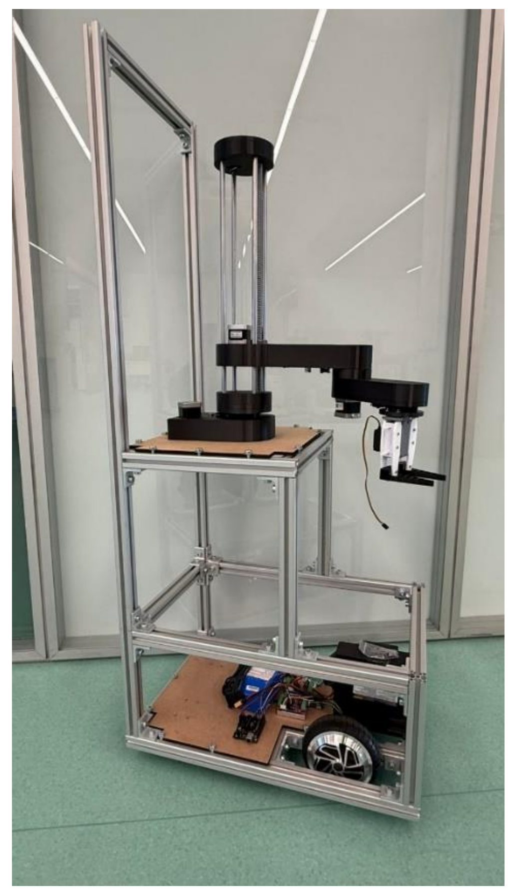


Figure III.2 – Robot in a real environment

In addition to the mechanical structure, the prototype was built with two batteries: a 12V stationary battery, which—through voltage regulators—powers the robot's logic system and robotic arms, and a 36V lithium-ion battery (36V Li-ion Battery) used to supply power to the drive wheels.

The entire motor drive system was implemented using a hoverboard system, incorporating its battery, wheels, and sensors. Control is managed via RioRand ZS-X11H motor controller boards, driven by the central system using ROS Serial in communication with an Arduino board.

Table III.1 presents the final specifications of the prototype in its first version.

Table III.1 – Robot technical information.

Robot version	**2025**
Dimension LxPxA	400mm x 600mm x 1679mm
Total weight	48kg
Driving motors	brushless 36V
Control Board	RioRand ZS-X11H
Wheel diameter	8 pol
Max Speed	< 1m/s - (limited by the board)
Battery 1	Li-ion 36V
Battery 2	VRLA 12MVA18 - 18Ah
Autonomy	~ 1 hour

IV. The future

As this is the team's first participation, no direct comparisons with previous prototypes are possible. However, the following areas of improvement were identified:

- Enhanced human–robot interaction.
- Multimodal dialogue (speech + gestures) using AI.
- Improved navigation system with greater accuracy and robustness.
- Adjustments to robotic arms for improved precision and rigidity.
- Increased autonomy and more efficient battery charging system.

V. Conclusions

This first prototype is already functional, though not all proposed features are fully implemented. The hardware platform is prepared for future developments, but the focus for this version was on building and programming the basic functionalities required for competition.

The current platform serves as a solid foundation for future enhancements and provides a useful reference for other new teams entering RoboCup@Home, in a competition that already includes many experienced teams with highly mature projects.

VI. Acknowledgment

We thank professors Alexandre, Daniela, and Julia for their guidance and support since the beginning of this journey. We also acknowledge Universidade Paulista for making this prototype development possible and supporting the team's participation in the competition, which has challenged us and complemented our academic training with a unique learning opportunity.

VII. References

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