H.E.S.T.I.A

HOUSEHOLD EFFICIENT SERVICE TASK-INTEGRATED ASSISTANT

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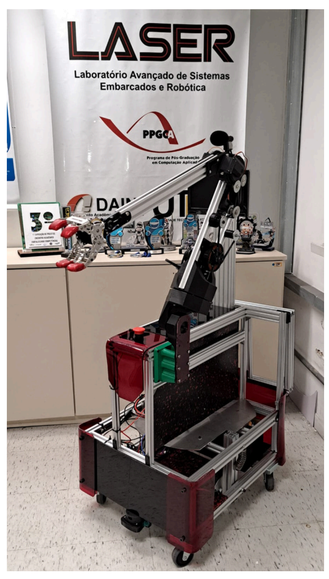
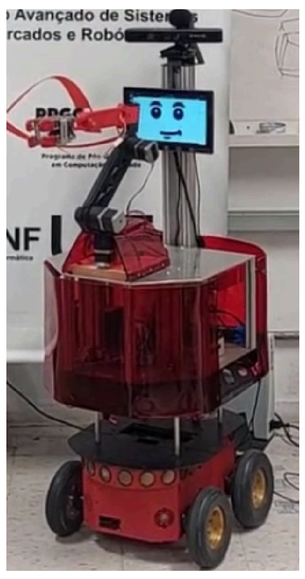
Introduction

H.E.S.T.I.A. is **UTBots's** new autonomous domestic service robot for **Robocup@Home**. Featuring a new complete redesign of the mobile base and robotic arm, it integrates new software for navigation, object detection and natural language processing with two task orchestration models, State Machines and Behaviour Trees.

Design	H.E.S.T.I.A.	Apollo (2023)
Mobile Base	 Built with aluminum extrusions and metal plates, we used hoverboard brushless motors with a custom firmware for Field Oriented Control[1]	 A Pionner P3-AT commercial mobile base, controlled by a open-source ROS interface, RosAria[2]
Robotic Arm	5-DOF arm built from aluminum and 3D-printed parts, with brushless motors, cycloidal 25:1 gearboxes, magnetic encoders and ODrive drivers [3]	4-DOF arm built from 3D-printed parts, with stepper motors, planetary 50:1 gearboxes with custom control software
Battery	Upgraded to Li-ion batteries for smaller, lighter, and more energy-efficient power supply	Lead-acid batteries with 12V output

Software Solutions

The key software systems and approaches integrated into H.E.S.T.I.A.'s architecture:

- **Navigation System**: New navigation system with nav2 in ROS2 Humble, integrated with the remaining software implemented in ROS1.
- **Object Detection**: Upgrading to *YOLOv11*[4] simplified dataset training and usage while also improving recognition quality and accuracy.
- **Natural Language Processing**: The new Natural Language Understanding system, using *RASA*[5], improves the robot's ability to understand dialogues. It detects intentions, provides responses, triggers actions, and identifies entities like object or room names. The implementation of a Language Model with *llama.cpp*[6] gives H.E.S.T.I.A. the capability to answer context-driven open questions.
- **Task Orchestration**: H.E.S.T.I.A. introduces a new approach to task execution using State Machines and Behavior Trees. Tasks are orchestrated with these methods, where State Machines are easier to implement but best suited for simple, unreactive tasks. Behavior Trees are more complex, however handle reactive tasks better.

Conclusion and Future Work

H.E.S.T.I.A. upgraded design and capabilities allow a more robust structure of implemented Robocup@Home tasks. Planned improvements include an intelligent battery management system, as an adaptive and precise manipulation control and task planning upgrades.

References

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