ACSO - BahiaRT@Home

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Introduction

The ACSO - Research Center in Computer Architecture, Intelligent Systems and Robotics at the State of Bahia University - UNEB, Brazil, introduces the service robot BILL (the Bot, Intelligent, with Large capacity and Low cost).

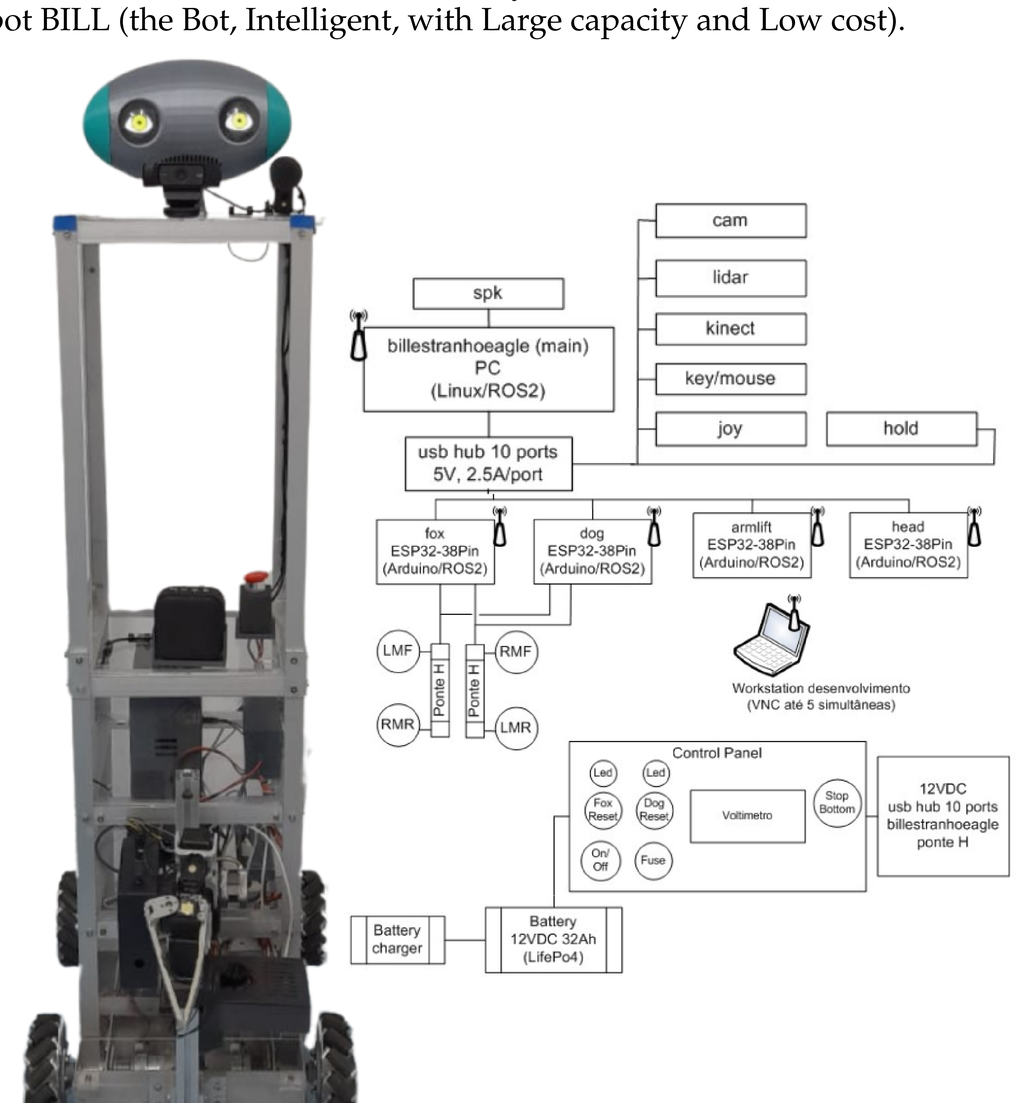

Figura 1: BILL Estranho

BILL's Capabilities

- 3D environment recognition, with the Depth Camera data of ASUS Xtion. Surpassing the last year, the team has improved BILL's 3d vision skils. Now, generating a point cloud with th OpenNI2 driver, BILL received the ability of finding objects and people positions;
- People Recognition, using a Deep Neural Network (DNN) model from the OpenCV library for facial detection, and the Dlib library for facial recognition;
- Manipulation, using a mechanical arm with 5 servos Dynamixel-12A, allowing object mobility with its claw;
- Motion, using 4 Mecanum Wheels, which allows it to move in any direction and turn around its own axis with ease;
- Navigation, using encoders, ROS 2 modules, and a 360° laser scanner for accurate robot control, mapping, and obstacle avoidance, as well as ros2 control framework;
- Speech Recognition and Voice, using Piper-TTS v1.3.0 software to enable voice interaction and Ollama Qwen v2.5 model for understanding and generating responses in natural language.

Main Contributions to the RoboCup@Home League

Fox-Dog Fault Tolerance System:

BILL features a fault-tolerant motor control system with two redundant ESP32 microcontrollers. Inspired by predator-prey behavior, each monitors the other to ensure immediate takeover in case of failure, enhancing reliability and safety. This system is currently in development and planned for future implementation.

Human-Robot Interaction

The 2025 generation begins the development of an interactive physical interface between human and robot, enabling expressive communication aligned with BILL's mechatronic system. BILL currently uses sensors and two servos (4.8V–7.2V) — one for horizontal and one for vertical movement — controlled by an ESP32S 38p, allowing basic motions like head rotation and neck tilt for more natural interaction.

Initial motion patterns include looping movements (right to left, up and down), with the goal of BILL autonomously making eye contact with the user. LEDs will be added to the mouth area to light up according to the user's speech, with brightness modulated by audio output. As of now, the structure includes a shoulder, neck, and head made from PLA using a 3D printer, forming the physical base of the interface.

This interface is key for BILL to exhibit reactive and expressive behavior, enhancing both social interaction and effectiveness in assistive tasks. It also supports research in service robots within the @Home context, aiming to improve empathy and interaction in home environments.

Figura 2: Controled head for HRI

Object Recognition Using YOLO and OCR

BILL integrates YOLOv8 for real-time object detection with Tesseract OCR for reading labels. This hybrid system allows the robot to accurately identify and distinguish labeled items, such as packaged food or household products, even when visual similarity is high.

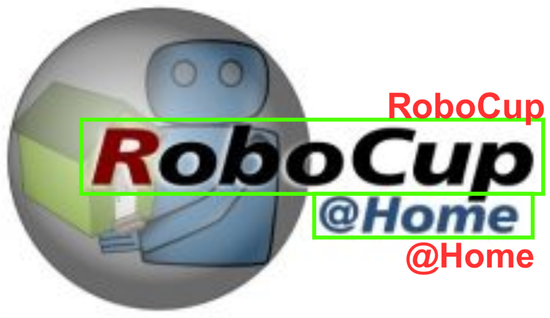

Figura 3: BILL's OCR demo

Conclusion

BILL Estranho demonstrates progress over its previous version, particularly in the areas of HRI, speech and object recognition. The integration of AI with natural language speech recognition provides BILL with a versatile communication tool, greatly enhancing its interaction capabilities. Furthermore, the combination of object detection and Optical Character Recognition (OCR) improves BILL's precision in identifying objects that contain text. In addition to that, the use of ROS 2 Control framework enhances its hardware integration and motor control. Furthermore, BILL had improved its HRI with the development of the head. Together, these advancements make BILL a versatile, intelligent, and user-friendly service robot, capable of navigating dynamic environments, interpreting complex inputs, and engaging with users in a natural and inclusive manner. All of our open source contributions can be found at our GitLab repository: `https://gitlab.com/bahiart/athome`

Partners: