AURIS: Autonomous Unified Robotic Intelligence System For Domestic Assistance

Natalie Esperanza Rojas Levi[1], Liliana Andres Guerrero Ibarra[2], and Daniela Yinniva Romero Padilla[3]

[1] SERENE SPA
sistematic.enviroment.spa@gmail.com
[2] Universidad Nacional Andrés Bello (Andrés Bello National University), Antonio Varas Campus, Chile

Abstract. AURIS (Autonomous Unified Robotic Intelligence System) is a domestic assistance robot designed to support people with reduced mobility, particularly older adults. It monitors its environment to detect critical situations such as falls or breathing difficulties and activates alerts when required. Through hand-tracking technology, AURIS assesses health conditions and adapts to user needs, promoting trust, security, and transparency by displaying in real time how it perceives its environment and makes decisions. Its AI operation follows ethical principles aligned with universal human rights and UNESCO guidelines, enhancing household quality of life.
This system integrates artificial vision, multimodal reasoning, biometric sensors, and an adaptive AI model. It is implemented in Python using the ROS2 framework in a Linux environment, combining software and hardware development tools such as Visual Studio Code, Autodesk Fusion, and KiCad [1] [2]

Keywords: Assistive Robotics · Computer Vision · Autonomous Navigation · Human-Robot Interaction · Emotional AI · Domestic Robotics

1 Introduction

The World Health Organization (WHO) estimates that by 2030, one in six people globally will be 60 or older. This age group is expected to grow from 1 billion in 2020 to 1.4 billion by 2050, resulting in a rise in the number of older individuals in global populations. Given this trend of progressive aging, there is a growing need for domestic assistance technologies designed for households to help support independent living.

We created AURIS, an autonomous domestic robot that operates in real-life environments to support users. With multimodal perception and adaptive AI, AURIS monitors users' health conditions, enhancing safety and promoting independence. It prioritizes transparency by displaying in real time how it perceives its environment and makes decisions, helping users understand its operations and reducing uncertainty about autonomous technologies.

This was achieved due to the integration of artificial vision, multimodal reasoning, and biometric sensors, along with an adaptive AI model, implemented through Python over the framework ROS2, executed in a Linux environment. The robot's development employs tools like Visual Studio Code, Autodesk Fusion, and KiCad, seamlessly integrating technical aspects with ethical considerations. AURIS aims to enhance household robotic assistance while prioritizing respect and responsible care. [3]

1.1 Team presentation - AukanBot@home

AukanBot@Home is a multidisciplinary Chilean team of undergraduate and postgraduate students partnered with a tech start-up, focusing on academic research. With expertise in computer science, robotics, civil engineering, and construction, they develop innovative solutions in the domestic and care sectors. Their mission is to advance service robotics through a collaborative approach that prioritizes user autonomy, safety, and quality of life, transforming specialized knowledge into impactful technologies for the community. [4]

1.2 General Objectives

Design and implement an autonomous robot to assist people with reduced mobility, especially older adults in home environments, using artificial intelligence and multimodal perception to increase the user's autonomy, safety, and well-being through reliable and ethical support.

1.3 Specific Objectives

- Develop proactive interaction mechanisms that allow the robot to recognize emotional cues and initiate support without explicit commands, including user recognition to customize interaction strategies and ensure a respectful, inclusive relationship.
- Develop computer vision and reasoning abilities for the robot to interpret its environment, autonomously navigate, and perform tasks like cleaning, retrieving, and organizing objects in dynamic settings
- Provide clear verbal and visual feedback by designing and integrating a visual interface that displays the system's perception, planning, and execution processes in real time, strengthening interpretability and user confidence.
- Implement a basic triage system aimed at detecting critical events, such as falls or breathing difficulties, and activating predefined alert protocols.
- Ensure that the system's decisions are governed by human-centred ethical principles, aligned with UNESCO guidelines and human rights.

2 Research Focus And Motivation

2.1 Main Areas

AukanBot@Home is developing an autonomous domestic robot capable of managing domestic environments. Its functioning presents the next key areas:

- **Multimodal perception and contextual comprehension:** Used for object recognition, surroundings interpretation, and everyday situation identification through multiple sensors.
- **Proactive interaction and adaptive human-robot:** It emphasizes emotion recognition and natural communication for warm, clear interactions.
- **Autonomous manipulation and navigation:** Centered around the movement and manipulation of objects safely and efficiently inside the home, adapting to changing surroundings and the presence of people.
- **Emergency detection and triage:** Recognize critical situations like falls, difficulty breathing, or loss of consciousness through the analysis of visual and biomedical signals.
- **Ethical and transparent decision making:** It ensures that the actions taken by the robotic system adhere to principles of security, respect, inclusion, and non-discrimination.

2.2 Challenge Identified

- The development of domestic robots capable of social interaction involves a series of interdisciplinary challenges that combine technical, cognitive, and ethical aspects.
- Achieving effective perception and situational awareness requires reliable detection and real-time interpretation of subtle signs from the domestic environment, including changing lighting, clutter, and unpredictable human behavior. [5]
- Domestic robots should promote intuitive communication for users of different ages and abilities, ensuring ethical clarity in their intentions and decisions. User trust relies on this transparency
- Safe domestic manipulation is a technical challenge that requires skills to handle objects and navigate confined spaces safely for both people and the environment.
- Precise identification of emergencies, such as falls or distress signals, must be achieved while strictly minimizing false alarms, so that the system maintains credibility and operational effectiveness.

3 Technical Challenges

To guarantee the autonomous and trustworthy operation of AURIS in domestic surroundings, we included advanced software and hardware. The technical challenges faced in this design are associated with robust perception, autonomous decision-making, human-robot interaction, and preventive security supervision. Each point discussed pertains to the modular architecture built on open technologies, along with software and hardware components specifically designed for this project.

3.1 Main Subsystems Of The System

Main subsystems of the AURIS system are composed of three main subcategories:

- **Autonomous Robotic Operation in Shared Environments:** It's designed to operate safely in domestic circles, which prioritizes collision avoidance and makes assistance decisions without any direct physical contact.
- **Adaptive Artificial Intelligence:** Models developed specifically for this project, focused on environment perception, contextual reasoning, and progressive adaptation of behavior. These models enable AURIS to identify and understand its surroundings and modify its basic functions based on prior interactions and conditions.
- **Coordination and automatization of tasks:** The system features planning and coordination mechanisms that enhance autonomous operation. By integrating these subsystems, it achieves a modular architecture that promotes autonomy, adaptability to its environment, and user-focused operations.

3.2 Multimodal Perception and Contextual Understanding

AURIS recognizes objects, detects relevant situations, and interprets the condition of the environment and the user through a multimodal perception system that integrates artificial vision, depth information, and environment monitoring. This combination enables real-time object detection, analysis of domestic scenes, and identifying patterns of behavior, providing the system with contextual understanding that supports autonomous and proactive decisions.

3.3 Autonomous Navigation and Operation

The robot uses a navigation framework based on ROS 2, which allows movement in a safe way inside dynamic interior environments through localization methods and Simultaneous Localization and Mapping (SLAM), obstacle evasion, and route planning. This function allows AURIS continuous operation in changing domestic spaces and the realization of assistant-like actions.

3.4 Proactive Human-Robot Interaction

AURIS combines verbal interaction and visual feedback to establish a natural and accessible communication with its users. According to perceived context and the functional profile of the user, the system is capable of proactively initiating interactions, adapting its communicating behavior to environmental conditions and the user's profile. This allows assistance without explicit instructions, maintaining a comprehensible and transparent interaction.

3.5 Safety Monitoring and Basic Non-Clinical Triage

The system has a triage mechanism that detects critical situations by analyzing visual information, behavior patterns, and biomedical indicators. AURIS can identify falls, prolonged immobility, or difficulty breathing andactivates monitoring protocols or alerts to enhance user safety.

3.6 Transparency and Ethical AI

AURIS integrates transparency and explainability (XAI) mechanisms that help users understand how the system behaves. To do this, the robot uses VizBox, a visual interface that displays real-time information about perception, planning, and execution processes, allowing users to see what information has been detected by the system and what actions are in progress or planned. Based on person-centred artificial intelligence, the system makes autonomous decisions that prioritise the safety of the user.

These principles are enforced through clear action planning restrictions, measures to prevent intrusive behavior, and confirmation mechanisms in sensitive situations. The system also promotes inclusive and non-discriminatory design for consistent behavior across various user profiles and environments. This enables AURIS to operate autonomously and responsibly in real homes, enhancing user confidence and aligning with international AI ethics and RoboCup@Home competition criteria.

3.7 Innovation Through Multidisciplinary Integration

The AURIS robot combines mobile robotics, adaptive AI, human-robot interaction, multimodal perception, and applied ethics into a single home automation platform. Built on ROS 2, it enables environmental perception, autonomous decision-making, and user interaction, while the VizBox interface helps users understand its behavior.

By integrating biometric sensing and behavioral analysis, AURIS facilitates early detection of critical situations through preventive monitoring. This approach adheres to person-centered AI principles, emphasizing safety, accessibility, and respect for users, and represents a significant advancement in the RoboCup@Home context.

4 Software Architecture

AURIS has a modular and distributed software architecture designed for safe operations in homes. Built on Linux and using ROS 2 as its main middleware, it facilitates real-time communication and includes QoS configurations for secure event handling. The platform is organised into central computing unit systems: Raspberry Pi with ROS 2 for high-level perception and intelligence, while secondary controllers: ESP32 support low-level control, decoupling high-level decisions and real-time control.

- **Perception and Environment Status Layer:** Includes ROS 2 nodes responsible for:
  - **Visual and Multimodal Perception:** Object detection and scene analysis; integration of depth/environmental status when available.
  - **User perception:** Extraction of observable signals (abnormal movement or falls) and an alternate communication channel using hand tracking for emergency gestures.
  - **Fusion and context:** Construction of a contextual state of the home and the user, published as 'system/user state' messages for consumption by the decision modules.
- **AI and Inference Layer (Python):**The artificial intelligence module is implemented in Python and operates as a set of inference nodes, like adaptive inference, adjusting behaviour parameters based on interaction history and environmental patterns within security policies, or event prioritisation, generating 'risk' or 'attention' signals for the triage module and for assistance logic.
- **Autonomy and Planning Layer:**Orchestrates overall behaviour through state/behaviour management and Task planning, defining modes such as domestic patrol, assistance, interaction, reinforced monitoring, and alert, and selects actions based on the perceived context (daily assistance, user confirmation, reinforced monitoring, protocol activation).
- **Navigation and Movement Layer:**(ROS 2) Includes nodes for SLAM/localisation, route planning, and indoor obstacle avoidance. Also includes execution of navigation objectives through actions (e.g., 'go to point', 'follow route') to facilitate RoboCup testing with variable scenarios.
- **Human–Robot Interaction Layer (HRI):**Includes verbal interaction (ASR/TTS depending on system availability) and contextual dialogue, also understanding user feedback through status messages, confirmations, and alerts, integrating a hand-tracking module when verbal communication is not possible.
- **Security and Basic Non-Clinical Triage Layer:**Implements an early detection and prioritisation mechanism without medical diagnosis: Consumes perceptual events (fall, immobility, apparent breathing difficulties), and classifies the status into priority levels and decides between confirmation, enhanced monitoring, or alerts. Publishes critical events with appropriate priority/QoS and activates defined protocols, like notifying a caregiver.
- **Transparency and Observability Layer:**The VizBox interface is powered by ROS 2 to display in real time active perception (what was detected), planning/decision status (what is to be done and why), and action in progress (navigation/interaction/protocol), improving interpretability and confidence, an aspect that is particularly valued in RoboCup@Home.

5 System Overview

AURIS was tested in residential environments to assess its autonomous navigation, environmental perception, human-robot interaction, and safety monitoring. The system consistently performed well in obstacle avoidance, object retrieval, user adaptation, and preliminary detection of critical situations, proving its viability for real domestic use.

5.1 Structural Simulation Observations

Structural simulations allowed the behaviour of AURIS to be evaluated in different scenarios, considering lighting, room an object variations. The main observations obtained are:

1. **Navigation Stability:** AURIS maintained stable navigation in indoor spaces, including small or partially congested areas, demonstrating its ability to adapt to obstacles, though a slight decrease in visual recognition accuracy was observed in low-light environments, reflective surfaces, and irregular trajectories, posing challenges for perception and movement.
2. **Interaction with objects:** The manipulation of visible objects on flat surfaces was consistent, but performance declined with partially hidden or irregularly shaped objects.
3. **Social navigation:** The robot adapted its trajectory to unpredictable user movements, maintaining a safe distance and ensuring smooth motion for safe interaction.
4. **Safety monitoring and event detection:** Preliminary detection of falls and prolonged immobility was mostly consistent, but occasional failures occurred due to limited viewing angles. Using sensors with broader coverage could improve reliability.

6 Real World Impact

The AURIS project aims to create a positive impact in domestic environments by addressing functional, security, and interaction challenges for seniors and individuals with low mobility. It features a transparent interface to enhance user understanding, independence, and safety during daily activities through autonomous operations.

AURIS includes an early detection triage system for critical situations, enabling quick responses via monitoring and alert protocols, thus improving response times without needing medical diagnoses. The project showcases a viable autonomous robotic system for home environments, utilizing multimodal perception, autonomous planning, and social adaptive interaction within a ROS2-based architecture.

In summary, AURIS offers a scalable, replicable domestic assistance solution that aligns with ethical principles and the evaluation criteria of the RoboCup@Home competition.

7 Conclusion And Future Work

This work presented AURIS, a domestic social autonomous robot based on a modular and distributed software architecture, implemented on ROS

2, that integrates multimodal perception, autonomous planning, proactive human-robot interaction, and preventive safety supervision mechanisms with a person-centred approach in real domestic environments.
The initial assessments through simulation scenarios confirmed the proposed method's effectiveness in enhancing indoor autonomy and ensuring user safety during emergencies. Likewise, the incorporation of a transparency mechanism, like the VizBox interface, contributes to improving the interpretability of system behaviour and user confidence.
In future work, we will test physical prototypes to assess system efficiency in real conditions, focusing on improving perceptual robustness, manipulation capabilities, long-term behavioral adaptation, and an ethical framework for autonomous decision-making. Together, these advances seek to consolidate AURIS as a practical, transparent, and reliable autonomous domestic assistance platform, aligned with the evaluation criteria of the RoboCup@Home competition and geared towards its responsible integration into everyday life.

References

1. Savioli et al. Geriatric Population Triage: The Risk of Real-Life Over- and Under-Triage in an Overcrowded ED: 4- and 5-Level Triage Systems Compared: The CREONTE (Crowding and R E Organization National TriagE) Study. Journal of Personalized Medicine. **14**(2), 195 (2024). https://doi.org/10.3390/jpm14020195
2. UNESCO: Una inteligencia artificial ética e inclusiva en América Latina y el Caribe. https://www.unesco.org/es/articles/una-inteligencia-artificial-etica-e-inclusiva-en-america-latina-y-el-caribe-la-unesco-presenta-su, last accessed 2026/02/10
3. Population Matters: The Facts and Numbers. https://populationmatters.org/the-facts-numbers/, last accessed 2026/02/10
4. Wang, Y., Chen, H., Cheng, H., Qiu, J., Huang, R., Zou, C., Song, G., Liu, M., Liu, Q., Zhang, J., Hu, X.: The attitudes and acceptance of functional assistive robots among older adults with disabilities: a mixed-methods study. Innovation in Aging **9**(9), igaf097 (2025). https://doi.org/10.1093/geroni/igaf097
5. Bavle, H., Sanchez-Lopez, J.L., Cimarelli, C., Tourani, A., Voos, H.: From SLAM to Situational Awareness: Challenges and Survey. Sensors **23**(10), 4849 (2023). https://doi.org/10.3390/s23104849