Technical Manual of the AURIS Robotic System

Autonomous Domestic Assistance Robot

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Robot Identification

General System Identification

Item	Specification
Nombre del sistema	AURIS
Acronym	Autonomous Unified Robotic Intelligence System
System type	Autonomous domestic social assistance robot
Category	Domestic assistive and social robotics
Operating domain	Residential indoor environments
Project	AukanBot@Home
System status	The AURIS system is currently in a functional prototype state. Its validation has been carried out mainly through structured simulation and controlled testing, aimed at evaluating architecture, perception, navigation, interaction and safety within the RoboCup@Home context.
Operating mode	Autónomo, proactivo y supervisado
Target users	Older adults, people with reduced mobility, people with mild disabilities, and households requiring assisted supervision.
Differentiating critical function	Integrated basic triage system for early emergency detection
Assistance focus	Domestic support, adaptive social interaction and safety supervision.
Ethical framework	Human-centred design, aligned with human rights principles and AI ethics.

Technical Classification of the Robot

Dimension	Classification	Detailed technical specification
Robot type	Ground mobile robot	Mobile robotic platform designed for autonomous movement in domestic indoor environments. It moves on electronically controlled drive wheels, optimised for flat household surfaces. It incorporates autonomous navigation with obstacle avoidance and adaptation to confined spaces.
Architecture	Distributed computing	The system employs a distributed architecture composed of a main computing unit (Raspberry Pi running Linux and ROS 2) and secondary microcontrollers (ESP32) dedicated to real-time control. Communication is performed via serial or network interfaces, separating high-level decision-making from low-level control.
Interaction	Human–Robot Interaction (HRI)	The robot implements social and assistive Human–Robot Interaction, integrating verbal communication, visual feedback and proactive behaviour. Interaction is adapted to the user profile (older adult, person with reduced mobility, etc.) and to the domestic environment context.
Autonomy	High level (decision + execution)	AURIS has high-level functional autonomy, capable of perceiving the environment, interpreting situations, making decisions and executing actions without continuous supervision. It includes task planning, autonomous navigation, basic manipulation and activation of safety and basic non-clinical triage protocols in critical events.
Learning	Adaptive artificial intelligence	The system incorporates an artificial intelligence model developed in Python that enables progressive adaptation of the robot’s behaviour. The model adjusts its decisions according to interaction history, environmental patterns and user behaviour, remaining within limits defined by safety policies.

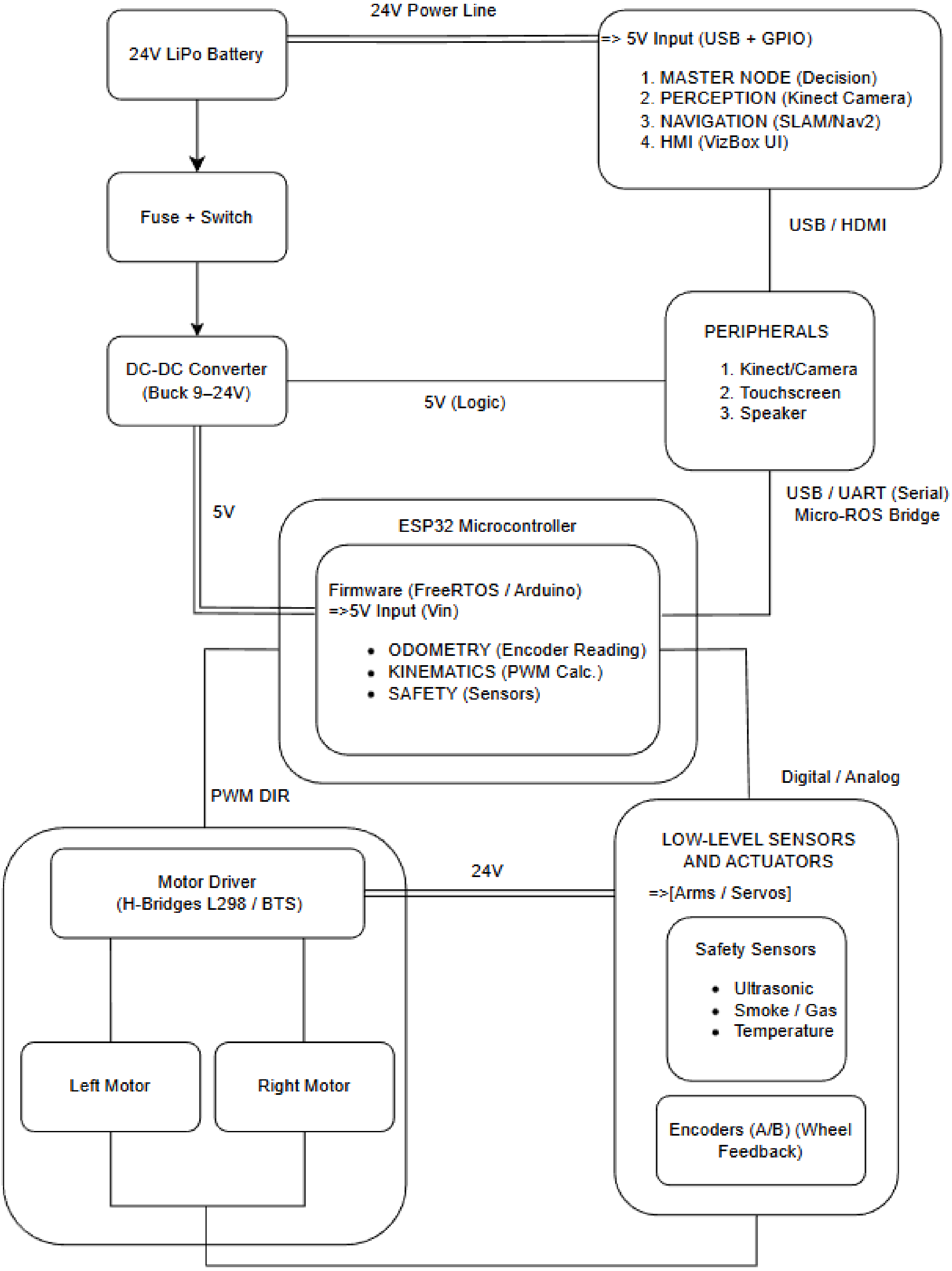
Transparency	Real-time visual interface (VizBox)	AURIS integrates a visual transparency interface (VizBox) that displays perception, planning and execution processes in real time. This interface allows the user to understand the robot's decisions, increasing trust, interpretability and compliance with human-centred AI ethical principles.

SYSTEM OPERATIONAL SCOPE

System architecture

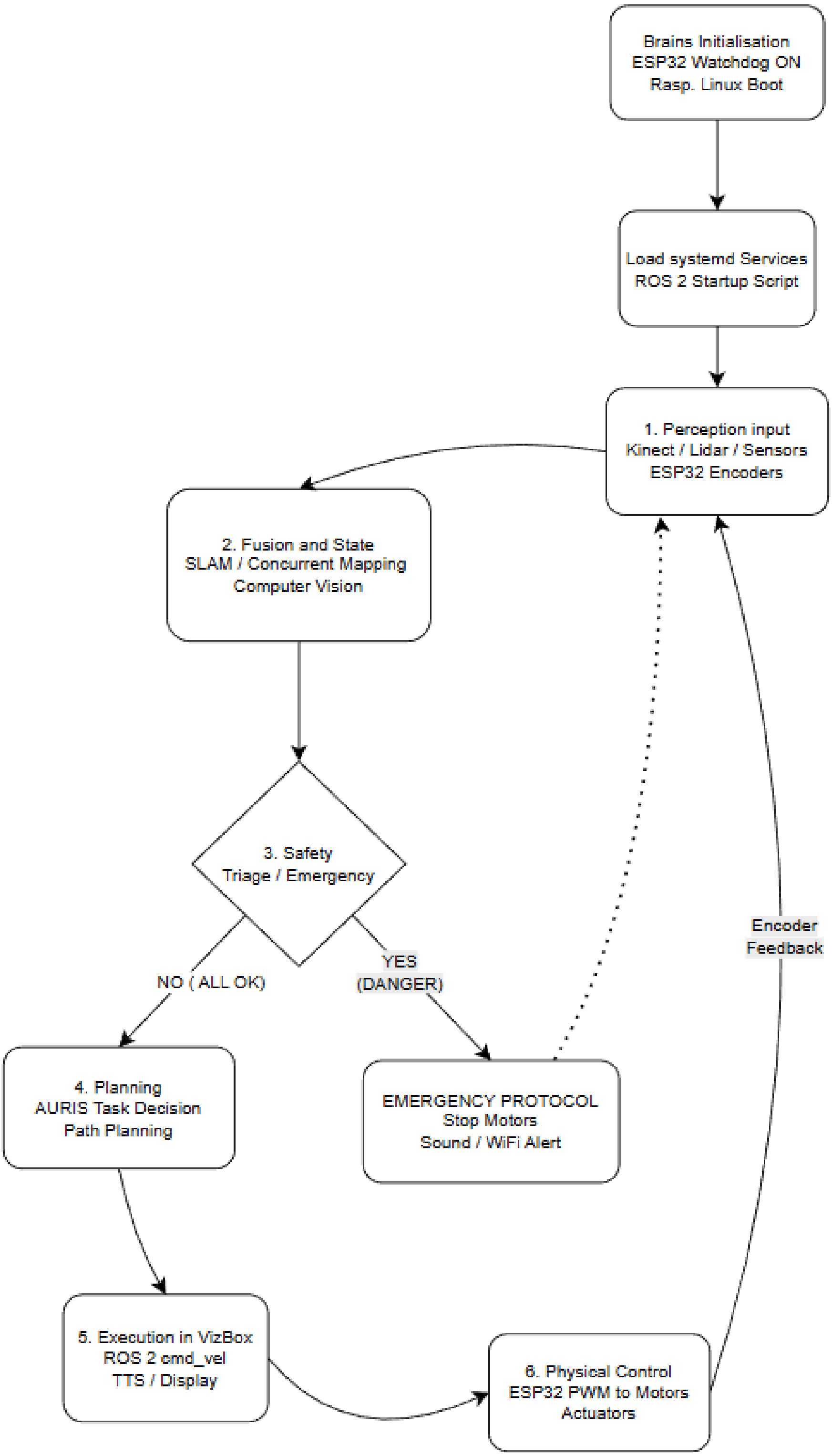
The system uses a distributed architecture based on ROS 2, running on Linux on a main computing unit, responsible for high-level perception, planning and inference. Low-level control and signal acquisition are delegated to ESP32 microcontrollers, communicated via serial or network interfaces. This separation enables robust and decoupled operation between decision-making and real-time control.

This diagram shows the integrated hardware and software architecture of the AURIS system, including power distribution, the separation between high- and low-level control, and the main communication flows between the main computing unit, the ESP32 microcontroller, the sensors and the actuators. This allows high-level decision-making to be decoupled from real-time control, improving system robustness and safety.



1.Electrical diagram

Control flow and decision-making of the AURIS system, from system initialisation to the execution of physical actions. The diagram shows the integration between perception, information fusion, safety evaluation through basic non-clinical triage, autonomous planning and low-level control, as well as the handling of emergency events and the system feedback loop.



2. *Flow Diagram*

The AURIS architecture explicitly separates safety-critical processes and motion control from those that do not require strict temporal guarantees. Critical functions, such as motor control, encoder reading and safety sensor supervision, are executed on dedicated ESP32 microcontrollers, allowing a deterministic response at the local control level, independent of the high-level system.

Advanced perception, planning, artificial intelligence inference and Human–Robot Interaction processes are executed on the main computing unit under ROS 2. These modules can tolerate variable latencies without compromising system safety, as they do not directly intervene in immediate actuator control.

In the event of a loss of communication between ROS 2 and an ESP32 microcontroller, detected through temporal supervision mechanisms (heartbeat and timeout), the system automatically enters a fail-safe mode. In this state, the motors are immediately stopped and the safety sensors remain active. Resumption of operation requires explicit verification of the system state, preventing unsupervised automatic restarts and ensuring conservative behaviour in the presence of faults.

Permitted Operating Environment

AURIS is designed to operate **exclusively in domestic indoor environments**. Compatible scenarios include homes with flat and stable surfaces, such as ceramic floors, laminated wood and short-pile carpets. The system is not intended to operate outdoors, **nor in the presence of stairs**, pronounced level changes or environments with high humidity.

The maximum admissible slope corresponds solely to the normal **irregularities of a domestic floor**, ensuring safe and stable operation during autonomous navigation

The recommended operating conditions for system operation are as follows:

- **Operating temperature:** between 10 °C and 35 °C
- **Relative humidity:** between 30 % and 80 %, without condensation
- **Minimum corridor width:** 75 cm
- **Optimal width:** 90–100 cm
- **Maximum detectable obstacle height:** up to 2.0 m, through visual detection

Intended Use in RoboCup@Home

AURIS has been designed and developed to operate in accordance with the operational scenarios and principles established by RoboCup@Home, demonstrating functional, social and ethical capabilities in simulated and controlled domestic environments.

Within this framework, the intended use of the system is structured along the following functional axes:

Proactive human–robot interaction

AURIS is intended to operate autonomously in domestic indoor environments, using simultaneous localisation and mapping (SLAM) techniques implemented on ROS 2. The system is capable of moving safely in shared spaces with people, planning routes, avoiding obstacles and adjusting its speed and trajectory according to the context and user proximity, in accordance with the scenarios defined by RoboCup@Home.

Interacción humano–robot proactiva

The robot is designed to establish natural and understandable interactions with users, combining verbal communication and visual feedback. AURIS can initiate interactions proactively when it detects relevant situations in the environment or in the user's state, adapting its communicative behaviour to maintain clear, respectful and non-intrusive interaction, as required in the competition's social interaction tests.

Basic object retrieval

Within the RoboCup@Home framework, AURIS demonstrates basic manipulation and retrieval capabilities for lightweight domestic objects that are visible and accessible on flat surfaces. These actions are executed autonomously, prioritising user and environmental safety, and without requiring direct physical contact with people.

System transparency

The system incorporates explicit transparency mechanisms through the VizBox interface, which allows real-time visualisation of relevant information regarding environmental perception, planning status and actions being executed. This functionality is intended for both end users and RoboCup@Home judges and evaluators, facilitating understanding of the robot's internal behaviour without interfering with its autonomous operation.

Early detection of risk situations

AURIS integrates a preventive supervision and basic non-clinical triage system aimed at the early detection of potentially critical situations, such as falls, prolonged immobility, apparent respiratory difficulty or manual emergency gestures. In the context of the competition, this capability allows demonstration of the system's autonomous response to risk events through user confirmation, enhanced monitoring or activation of alert protocols, without performing medical diagnoses.

Autonomous Navigation

The robot's autonomous navigation system is based on simultaneous **localización y mapeo simultáneo (SLAM)** techniques, implemented on the **ROS 2** framework, enabling robust, modular and scalable operation. Through the fusion of data from perception sensors (such as lidar, cameras or proximity sensors), the robot is able to build and update a map of the environment in real time while continuously estimating its own position within it.

The navigation algorithm is optimised for domestic indoor environments, allowing safe movement through **standard-width corridors (90 cm to 100 cm)**, rooms and shared areas. The trajectory planner generates smooth and efficient routes, considering both the geometry of the environment and the robot's kinematic constraints.

To ensure safety in human–robot interaction, the system incorporates **dynamic speed control**, which automatically adjusts movement according to the proximity of people or moving obstacles.

When human presence is detected, the robot reduces its speed and maintains a predefined safety distance, minimising collision risks and increasing user confidence. When unexpected obstacles appear, the avoidance module evaluates possible alternative trajectories in real time. If a safe route exists, the system performs an automatic path replanning; otherwise, the robot stops its movement in a controlled manner and remains in a safe state until conditions allow navigation to continue.

In situations of total environmental blockage, the system recognises the impossibility of progress, completely stops the locomotion actuators and enters a safe waiting mode, avoiding forced or dangerous manoeuvres.

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Operating Parameters

- **Normal travelling speed:** up to 3 km/h
- **Reduced speed in the presence of people:** approximately 0.8 m/s
- **Behaviour in the event of total blockage:**
    - Safe detection of inability to move
    - Automatic path replanning
    - Transition to a safe waiting state if the blockage persists

Speed values are configurable and limited by software according to the environment and context.

Perception and Sensors

The AURIS perception system is designed to enable a robust understanding of the domestic environment and the user's state, integrating information from multiple heterogeneous sensors. This multimodal perception forms the basis for autonomous navigation, human–robot interaction, basic object manipulation and safety supervision.

AURIS primarily uses **artificial vision through cameras** and, when supported by the hardware, **depth sensors**, for the detection of objects, people, obstacles and relevant events in the environment. These sensors allow the identification of surfaces, distance estimation, recognition of human postures and the detection of potentially critical situations, such as falls or prolonged immobility.

Additionally, the system integrates **low-level sensors**, such as **wheel encoders**, which provide odometry information for navigation, and **environmental safety sensors** (for example, smoke, gas or temperature), used as additional mechanisms for environmental supervision. The reading and initial processing of these sensors is carried out on dedicated microcontrollers, ensuring adequate response times for critical functions.

Perceptual information is fused on the main computing unit under ROS 2, where the modules for contextual interpretation, planning and high-level decision-making are executed. This architecture allows AURIS to respond proactively to changes in the environment and to user behaviour, maintaining safe and coherent operation.

The performance of the perception system may be affected under adverse conditions, such as **low lighting**, **highly reflective surfaces**, **partial occlusions of objects** or **visually cluttered environments**. These limitations are explicitly considered within the planning and safety mechanisms, so that, in situations of high perceptual uncertainty, the system adopts conservative behaviours, such as speed reduction, increased safety distance or requesting confirmation from the user.

Human–Robot Interaction

AURIS interacts with users through verbal **communication and visual feedback** via the **VizBox** interface, providing clear information about the system’s status and actions. In situations where verbal communication is not possible, the robot can employ a **hand-tracking** module to detect manual emergency gestures, enabling an alternative and accessible form of interaction.

Interaction is dynamically adapted to the context of the user and the environment, prioritising clear, **non-intrusive and easily understandable behaviour**. The optimal interaction distance ranges between **0.8 and 1.4 m**, promoting safe and comfortable communication.

If the user does not respond to an initial request, the system repeats the interaction and transitions to a **reinforced monitoring mode**. The maximum waiting time before changing strategy is **configurable**, with typical values between **20 and 30 seconds**, allowing the system’s behaviour to be adjusted according to the needs of the environment and the user.

Object Manipulation

The robot’s manipulation system allows the **retrieval and basic transport of lightweight domestic objects**, provided that they are **clearly visible, static and accessible on flat and stable surfaces**. The system design prioritises safe and controlled operation, oriented towards simple assistance tasks in domestic environments.

Manipulation is carried out through predefined movements of the extremities, coordinated by the control system, which allows grasping and transport actions to be executed in a repeatable manner. The system **is not designed to manipulate heavy objects, fragile objects, or objects that require direct contact with the user**, nor for tasks that involve physical interaction during the handover or reception of the object.

From a mechanical perspective, the robot’s extremities have been dimensioned to support loads within the established operational margins, maintaining **stable force and position control** during manipulation. During transport, the object is kept close to the robot’s body in order to preserve system stability.

Operating specifications

- **Approximate maximum object weight:**
    - Up **to 5 kg using both hands**
    - Up **to 2 kg per hand**
- **MPA (Actuator Protection Margin): 150 kg**
- **Typical object size::**
  Small domestic objects, with simple geometry and easy to grasp.
- **Examples of compatible objects:**
    - Plastic bottle
    - Remote control
    - Mobile phone
    - Lightweight container

Safety supervision and basic non-clinical triage

AURIS incorporates a **basic non-clinical triage system** aimed at the **early detection and prioritisation of potentially critical events**, with the objective of improving system safety and user support in domestic environments. This system **does not perform medical diagnoses or clinical evaluations**, and acts exclusively as a **preventive detection mechanism and decision-support tool**.

The events that the system is capable of identifying include:

- **Falls**
- **Prolonged immobility**
- **Apparent respiratory difficulty**
- **Manual emergency gestures**

Based on the available perceptual information, the system classifies each event into **priority levels**, which allows it to decide whether to request **direct confirmation from the user**, intensify monitoring or activate **previously defined alert protocols**.

The typical evaluation time is on the order of **seconds**, approximately between **2 and 5 s**, allowing a timely response without compromising system stability.

Sensors and information sources used

Event detection is based on the combination of multiple sensory sources, depending on the type of situation:

- **Falls:** artificial vision and postural analysis.
- **Prolonged immobility:** artificial vision and time monitoring.
- **Apparent respiratory difficulty:** visual perception and audio analysis.
- **Manual emergency gestures:** hand-tracking detection through vision.

Confirmation of sensitive actions

AURIS incorporates a **prior confirmation mechanism** for all actions considered sensitive, with the objective of ensuring user safety, personal space and comfort. This mechanism is **mandatory for all actions that may affect user safety or comfort**, and forms an integral part of the system's operational policies.

Whenever conditions allow, the robot requests **explicit confirmation from the user** before executing this type of action. Actions considered sensitive include, among others:

- **Physical approach to the user**
- **Manipulation of objects located in proximity to the user's body**
- **Activation of external alerts or notifications**

If no response is received within a configurable waiting time, typically between **5 and 10 seconds**, the system adopts **conservative behaviour**. Depending on the context and level of risk, this behaviour consists of maintaining a **reinforced monitoring mode** or activating a **predefined alert protocol**, avoiding at all times intrusive, abrupt or unsupervised actions.

Transparency and explainability

AURIS incorporates the **VizBox transparency interface**, designed to visualise in real time relevant information about environmental perception, planning status and the action currently being executed. This interface aims to improve system interpretability, strengthen user trust and facilitate understanding of the robot's behaviour, without interfering with its autonomous operation.

Additionally, **VizBox allows judges and evaluators to understand the internal state of the system during RoboCup@Home tests**, facilitating observation of perception processes, decision-making and action execution in a clear and non-intrusive manner.

Privacy and information protection

In order to safeguard the user's privacy and peace of mind, the **VizBox interface does not display or store sensitive personal information**. In particular, the system:

- Does not display direct images of the user or video recordings.
- Does not store conversations, audio recordings or spoken text.
- Does not present medical data or perform health diagnoses.
- Does not store detailed histories of personal behaviour.

The information presented is limited to **general and understandable messages**, such as the robot's operational status or the detection of a situation requiring attention, avoiding at all times the exposure of private details of the person or the environment.

Operating procedures

This section describes the basic procedures for safe and controlled operation of the AURIS system:

- Safe power on and power off
- Start of autonomous operation
- Behaviour in the event of sensor failures
- Activation of safe mode in the presence of critical errors

Validation and testing

Validation procedures

- **Navigation:** Evaluate stability in indoor spaces and the ability to avoid unforeseen obstacles in congested areas.
- **Object interaction:** Verify the retrieval of objects on flat surfaces. This test assesses robustness with objects of irregular geometries that are easily accessible.
- **Basic non-clinical triage:** Simulate abnormal postures or immobility to verify that the system activates the **reinforced monitoring** or alert protocol without generating excessive false positives.

Ethics and privacy

Data handling and privacy

- **No medical diagnosis:** The system performs **basic non-clinical triage**. It is explicitly programmed to detect events (falls, respiratory difficulty) but **not** to issue medical diagnoses, protecting legal and ethical responsibility.
- **Transparency (VizBox):** To mitigate the feeling of loss of control, the robot displays its internal processes. The user can always see what the robot is detecting and why it makes a decision.

Responsible use

- **Ethical framework:** Autonomous decisions are aligned with the **Universal Declaration of Human Rights** and UNESCO guidelines, prioritising safety and avoiding discrimination in the recognition of user profiles..