FEATURED PROJECT 01

ADIUTOR

Embedded Control and Autonomous Navigation for a Hospital Mobile Robot

CONTEXT	ROLE	APPLICATION	PERIOD
CDTA Robotics R&D	**Embedded Systems Engineer**	**Hospital Logistics**	**2023–2024**

Project Overview

Developed the embedded control and autonomous-navigation system for **ADIUTOR**, a differential-drive mobile robot intended to support logistical operations in hospital environments.
The work combined a 36 V BLDC propulsion architecture with STM32F407-based wheel control, encoder and Hall-sensor feedback, PID regulation, LiDAR perception, and reactive navigation. The navigation method was implemented and validated under ROS Noetic and Gazebo in indoor and multi-obstacle scenarios.

Engineering scope

- Designed the control architecture for two BLDC wheels driven by Kelly KBS-X motor controllers.
- Generated PWM speed commands and implemented braking and direction-control logic.
- Acquired feedback from Omron E6B2 encoders and motor Hall sensors through STM32 interrupts.
- Converted linear and angular robot commands into independent left- and right-wheel velocity references.
- Applied PID regulation for controlled and synchronized wheel motion.
- Developed an Input Space Sampling method for LiDAR-based obstacle avoidance and goal-directed navigation.

Physical ADIUTOR mobile robot platform, extracted from the project thesis.

CORE RESPONSIBILITY

Bridging power electronics, embedded firmware, closed-loop motion control, and autonomous-navigation logic.

System at a glance

36 V dual-BLDC propulsion
Independent wheel control for a differential mobile base.

2,000 PPR wheel encoders
Incremental motion feedback for odometry and control.

STM32 Cortex-M4 controller
Timers, interrupts, UART, and PWM generation.

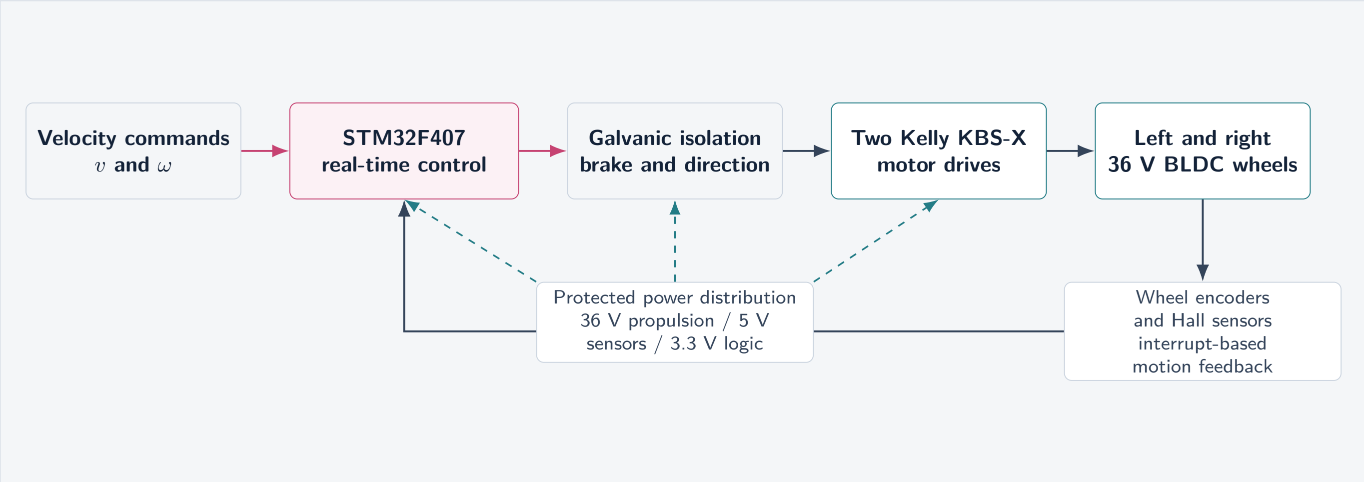
360-degree laser perception
RPLIDAR A2 operating range of 0.15–12 m.

TECHNOLOGIES

STM32F407VET6 · STM32 HAL · Embedded C · PWM · PID Control · BLDC Motors · Encoders · Hall Sensors · RPLIDAR A2 · ROS Noetic · Gazebo · RViz

EMBEDDED PLATFORM

Deterministic Control from Command to Wheel



Embedded motion-control architecture, recreated in English from the thesis system diagram.

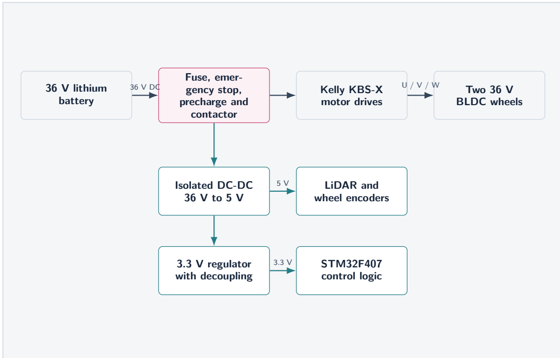
Control-loop implementation

The STM32F407VET6 forms the real-time motion-control layer. Linear and angular velocity commands are converted into individual wheel references. Encoder or Hall-sensor measurements provide feedback to the PID controller, which adjusts the PWM commands sent to the Kelly motor drives.

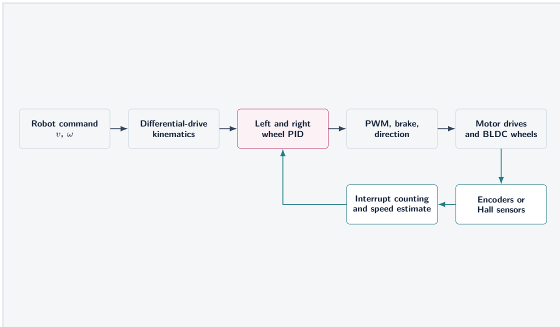
1. Receive the requested linear velocity v and angular velocity ω.
2. Calculate the right- and left-wheel velocity references using the differential-drive kinematic model.
3. Measure wheel motion through encoder or Hall-sensor feedback and calculate the control error.
4. Update the PID output and generate the corresponding PWM command.

Power and protection

The 36 V battery supplies the propulsion stage. DC–DC conversion provides 5 V for the sensors, followed by 3.3 V regulation for the microcontroller. The architecture incorporates a fuse, emergency stop, inrush-current limiting, flyback protection, and galvanic isolation between logic and motor-power domains.



Power distribution and protection, translated and recreated in English.



Closed-loop motor-control flow, translated and recreated in English.

Closed-loop control

Interrupt-based wheel feedback supports continuous correction of motor commands.

Electrical isolation

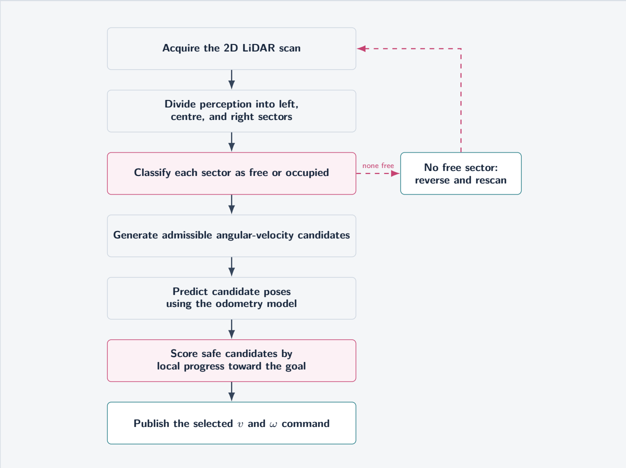
TLP521-4 optocouplers protect the low-voltage control electronics from the propulsion stage.

Safe actuation

Dedicated braking and direction logic prevents unsafe reversal while the wheels are rotating.

AUTONOMOUS NAVIGATION

LiDAR-Based Reactive Navigation and Simulation Validation



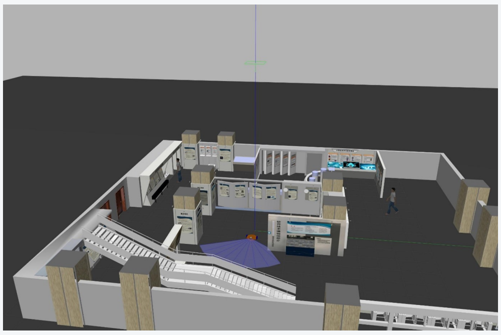
ISS pipeline translated into a concise English engineering workflow.

Navigation method

LiDAR measurements divide the robot's surroundings into free and occupied sectors. For every admissible direction, the algorithm predicts a candidate pose using the differential-drive odometry model. It then selects the safe candidate that produces the greatest local progress toward the target and publishes the corresponding linear and angular velocity command.

- Classify the forward, left, and right perception sectors.
- Generate admissible angular-velocity candidates.
- Predict the next pose for each candidate using odometry.
- Select the locally best collision-free motion toward the goal.
- Reverse and reassess when no admissible sector is available.

VALIDATION BOUNDARY
The autonomous-navigation results presented here were validated in ROS/Gazebo simulation. The physical embedded control architecture and the navigation simulation are therefore described separately.



Indoor Gazebo environment containing architectural and human obstacles.

Obstacle detection.

Completed avoidance manoeuvre.

SIMULATION RESULTS

Demonstrated LiDAR-sector classification, straight-line motion at $0.6\,\mathrm{m/s}$, multi-obstacle avoidance using angular commands of approximately $\pm 1\,\mathrm{rad/s}$, and goal-directed navigation from $(0,0)$ toward $(5,5)$ with automatic stopping inside a defined safety threshold.

PROPOSED 2026 ARCHITECTURE EVOLUTION — NOT YET IMPLEMENTED

- Migrate higher-level navigation to ROS 2 and Nav2 while preserving the STM32 as the deterministic motor-control layer.
- Add RGB-D perception and tracking to distinguish people and moving objects from static obstacles.
- Fuse encoder, IMU, and LiDAR measurements for more robust localization and SLAM.
- Extend ISS with predicted obstacle motion and integrate it beneath a map-based global planner.

Modernization does not mean replacing the STM32 with AI: deterministic control remains on the microcontroller, while perception, localization, and intelligent planning are added at the higher system layer.