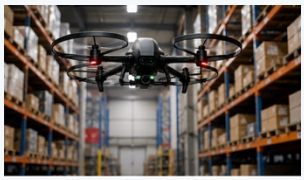
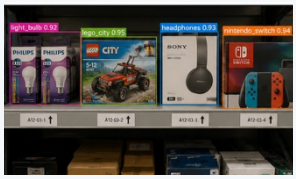
[IndRob-1] – Lost&Found Robots: Autonomous Search for Misplaced Products in E-Commerce Warehouses

Thesis sheet · PRISMA Lab

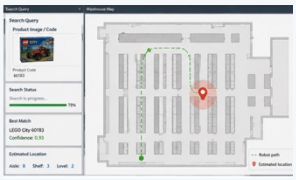
Mobile Robot inspecting warehouse



Aerial robot for indoor inventory



Product detection and visual matching



Lost-product localization on warehouse map

THESIS OVERVIEW

Modern e-commerce warehouses require accurate and efficient product localization. Even small placement errors, such as items stored on the wrong shelf or in the wrong aisle, may lead to delays, manual search operations, and inefficiencies in order fulfilment.

This thesis aims to develop a robotic system for the autonomous identification of misplaced products inside a warehouse. The system will receive as input either an image, a product code, or a short description of the missing item. A mobile robot or an aerial robot will then autonomously inspect the environment, acquire images of shelves and storage areas, and use machine-learning-based perception techniques to identify possible matches.

The expected outcome is a software pipeline integrating autonomous navigation, warehouse exploration, object detection, visual matching, and product localization. The final system should provide the estimated position of the misplaced object together with a confidence score for the recognition result. The thesis will be carried out in collaboration with Zerosem s.r.l., located in Lucca, and will include validation in simulation and, where feasible, on real robotic platforms.

TOOLS

Simulation & Middleware: ROS2 (Humble), Gazebo GZ, Matlab/Simulink
Languages & Libraries: Python, C++, OpenCV, YOLO/Ultralytics
AI / Perception: object detection, visual matching, image-based product recognition
Other: GitHub, Docker

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KEYWORDS

Warehouse robotics; autonomous navigation; object detection; visual search; product localization; mobile robots; aerial robots; machine learning; e-commerce logistics.

EXAMPLES / POSSIBLE ACTIVITIES

- **Track 1 – Autonomous Warehouse Navigation and Exploration**

Develop navigation and coverage strategies allowing a mobile robot to autonomously inspect warehouse aisles, shelves, and storage areas.

- **Track 2 – Product Detection and Visual Matching**

Implement machine-learning-based perception algorithms, such as YOLO-based detection, to identify candidate products from images acquired by the robot.

- **Track 3 – Lost-Product Localization and Confidence Estimation**

Associate visual detections with the warehouse map and estimate the position of the misplaced product, providing a confidence score for each possible match.

- **Track 4 – Image-, Code-, or Description-Based Product Search**

Develop a software interface that accepts a product image, product code, or textual description as input and translates it into a robotic search mission.

- **Track 5 – Mobile Robots vs Aerial Robots Detection**

Compare different robotic platforms for warehouse search tasks, analysing navigation feasibility, perception quality, inspection time, and operational constraints.

PREREQUISITES / NOTES

Recommended courses: Robotics Lab, Mobile Robots, Planning and Navigation, Artificial Intelligence, or perception-related courses.
Recommended skills: Python/C++, ROS/ROS2, OpenCV, and basic machine-learning tools are helpful.
Target degree: Master's students in Automation and Robotics Engineering or related programmes.
Note: The thesis will be carried out in collaboration with Zerosem s.r.l., located in Lucca. The final activity can be adapted toward navigation, perception, software integration, mobile robotics, aerial robotics, or industrial validation.

RELATED BIBLIOGRAPHY

- ROS2 Documentation – https://docs.ros.org/en/humble/
- Gazebo Simulator – https://gazebosim.org/
- Ultralytics YOLO documentation
- OpenCV documentation
- Literature on visual object detection and robotic warehouse automation