Project Report

Project Title:
Autonomous Warehouse Hunt: Shelf Sequencing, QR-Guided Navigation, and Inventory Recognition using SLAM, Nav2, and YOLO.

Project Description:
This project implements an autonomous mobile robot (the B3RB buggy) capable of exploring an unknown warehouse-like environment, locating shelves in sequence, decoding QR codes for directional heuristics, and performing object recognition and counting using a YOLO-based detector. The system integrates Simultaneous Localization and Mapping (SLAM) for map building and localization, Nav2 for global and local path planning, frontier-based exploration to discover new areas, and computer vision (QR decoding + YOLO object detection) to generate structured shelf inventory data.

Problem Recognized:
Large warehouses require frequent stock auditing. Manual counting is time-consuming, error-prone, and inefficient. Autonomous robots can reduce labor costs, improve accuracy, and enable continuous inventory updates.
This project simulates such a robot with a gamified treasure-hunt sequence.

What does the robot do?
- ➢ Builds a map of an unknown warehouse through SLAM.
- ➢ Locates shelves while avoiding obstacles.

➢ Decodes each shelf's QR code to extract: Shelf ID, heuristic direction (angle) to next shelf, and secret validation token.
➢ Identifies and counts visible objects using a YOLO-based detector.
➢ Publishes structured inventory + QR data to an evaluation topic.

High-Level Modules:

Module	Responsibilty
SLAM	Build occupancy grid + localization
Exploration	Frontier detection + goal selection
Navigation	Goal submission, feedback, recovery
Vision	QR decoding + object detection

Workflow:
1. Initialization:
Launch the simulation world.
SLAM begins mapping; Nav2 stack becomes ready.

2. Exploration Phase:
The robot detects frontiers (the boundary between known free space and unknown space). Chooses the closest acceptable frontier.

3. Shelf Detection:
Recognizes shelf footprint from occupancy grid.

4. Approach Shelf:
Nav2 goal set to an offset in front of the shelf.

5. QR Code:
Robot sidesteps to shelf side (left/right) for QR visibility.

6.   Camera frame processed: grayscale, contrast enhancement. pyzbar decodes QR string:
"<ID><Angle><SecretCode>".

7. Object Recognition Phase:
Realigns to front of shelf. YOLOv5 inference runs over multiple frames for stable counts.
Aggregates detected classes + counts.

8. Data Publication:
Creates WarehouseShelf message: object_name[], object_count[], qr_decoded.
Publishes to /shelf_data.
Repeat until final shelf processed.

Future Work
Pick and place integration.

Conclusion
This project shows that an autonomous robot can map a space, plan paths, read QR codes to unlock the next task, and identify objects automatically. Instead of manually checking shelves, the robot does it step by step. This shows how robots can help with automatic inventory work in real warehouses.