Indoor 3D-Sensor Based Navigation

Institute for Systems and Robotics Lisboa
SOCROB@HOME NAVIGATION

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PROBLEM STATEMENT

Install a 3D LiDAR to detect objects in 3 Dimensions to improve 2D Navigation of an autonomous domestic mobile robot

Avoiding **complex furniture** (such as one leg and legless tables) with a 2D sensor is challenging, leading to inevitable collisions in home environments. Using a sensor that provides 3D information is a **solution for this problem** enabling the robot to detect the mentioned obstacles.

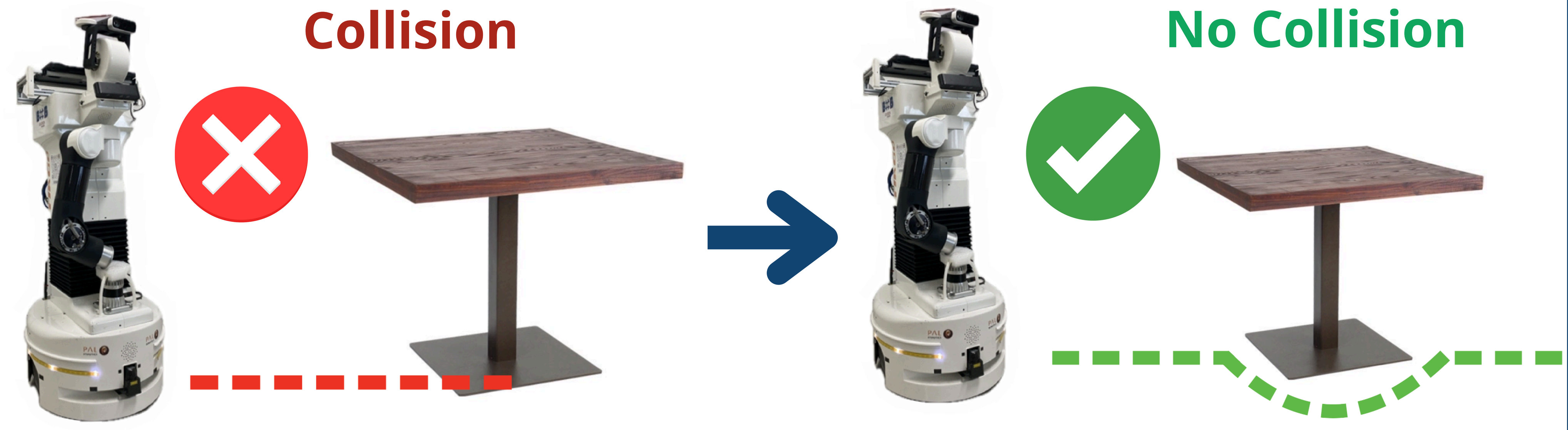


Figure: Left - Robot's path using a 2D laser that leads to a collision; Right - Robot's path using a 3D laser that does not lead to a collision

2D-SENSOR BASED NAVIGATION

This approach is **not an accurate** representation of the environment.

- Uses a 2D laser scanner to build a **2D map**.
- Detects chairs as obstacles due to their four legs **covering the surface area**.
- **Fails to detect** single-leg table surfaces.
- The robot will most likely **collide** with single-leg tables.
- Interprets complex objects as **static shapes or points** on the ground.

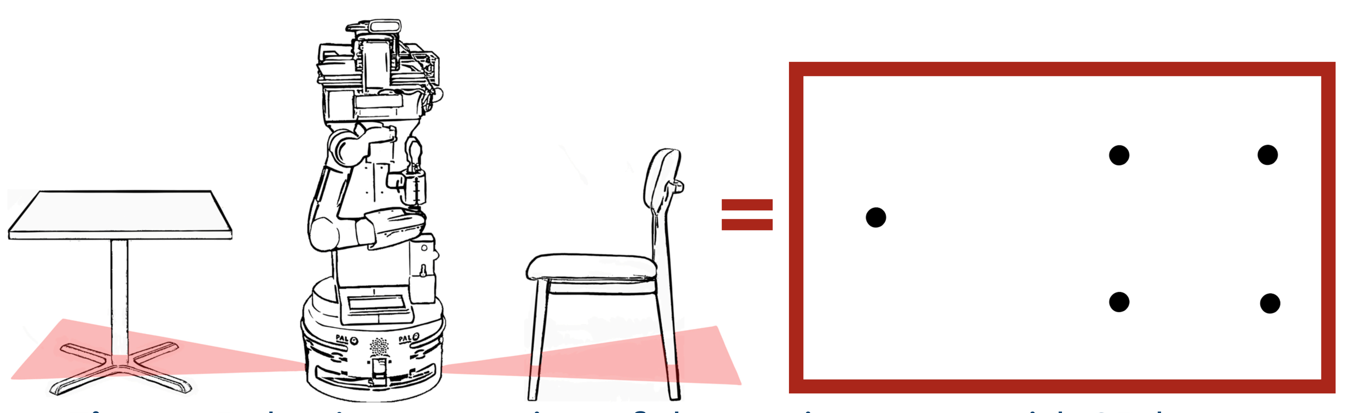
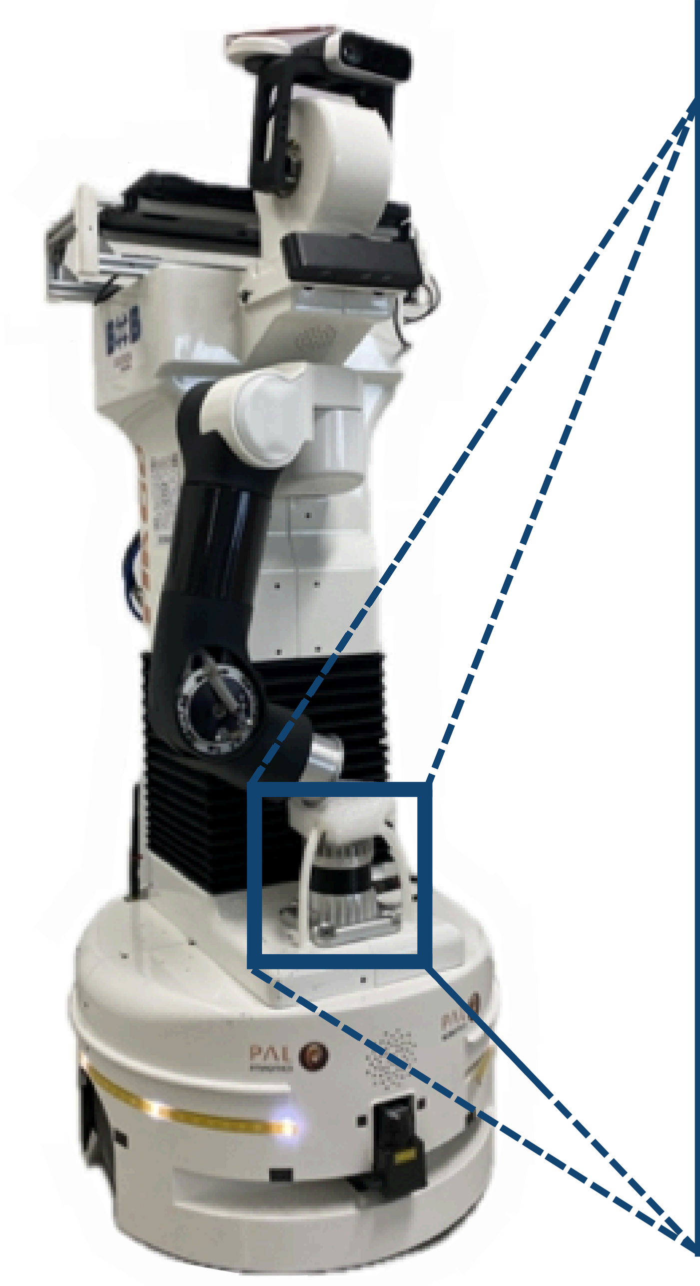


Figure: Robot's perception of the environment with 2D lasers



NEW 3D-SENSOR BASED NAVIGATION

This approach is **an accurate** representation of the environment.

- Uses a 3D laser scanner to build a detailed **3D map**.
- **Solves the main problem** of 2D-sensor navigation.
- **Fully maps complex objects**, such as single-leg tables.
- Avoids complex furniture, creating **paths around obstacles.**
- Provides information for more **accurate pathfinding**.

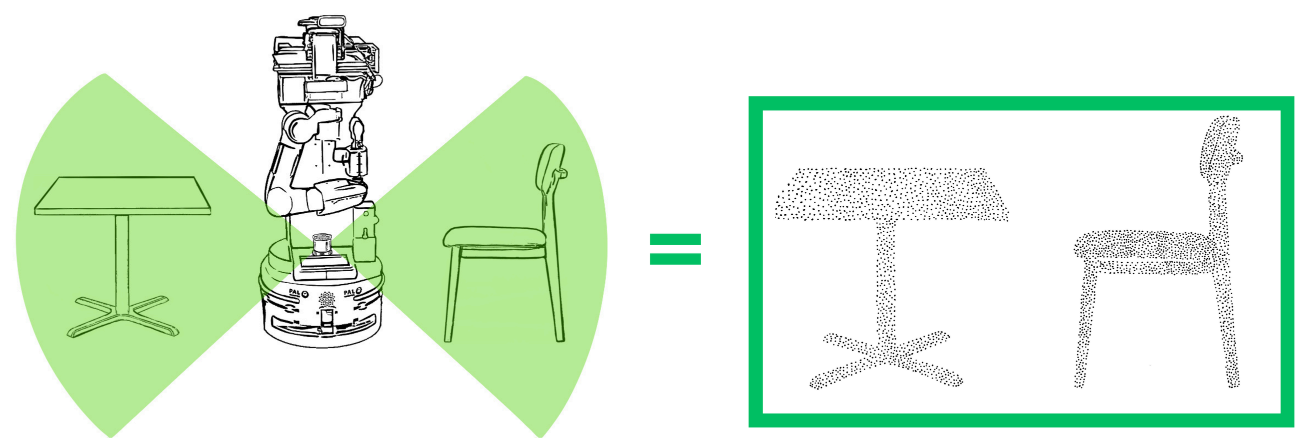


Figure: Robot's perception of the environment with 3D lasers

OUR SOLUTION

Improved obstacle detection was achieved by:

- The use of a **3D LiDAR** to generate 3D data.
- Processing data with a **3D mapping algorithm** which generates a map.
- **3D localization**, which allows real-time visualization of the environment.
- Adjusting the way the robot's **height and footprint** are handled, with both changes being taken into account.

Figure: Left - Hokuyo 2D laser scanner; Right - OS1 3D laser scanner

TESTING

Tests were carried out testing in both a simulated environment using Gazebo and RViz, and a real environment.

- **Simulated environment:** Evaluating the robot's navigation and path changes in a simulated testbed.
- **Real environment:** Navigation through a series of progressively more demanding obstacle courses.

Figure: Simulation environment

Figure: Testbed environment at ISR

RESULTS

The conducted tests had a **successful rate** equal to 100% in **simulation**, and equal or greater than 90% (out of 10 trials) in **real environment**. Conducted tests included: static, dynamic and gradually smaller obstacles.

Type of test performed	Number of successful trials (out of 10)
No obstacles	10
Static obstacles	10
Static obstacles + Obstacle that 2D-sensor based navigation doesn't avoid	10
Static obstacles + Obstacle that 2D-sensor based navigation doesn't avoid + Dynamic obstacle	10
Gradually smaller static obstacles	9

Table: Test results

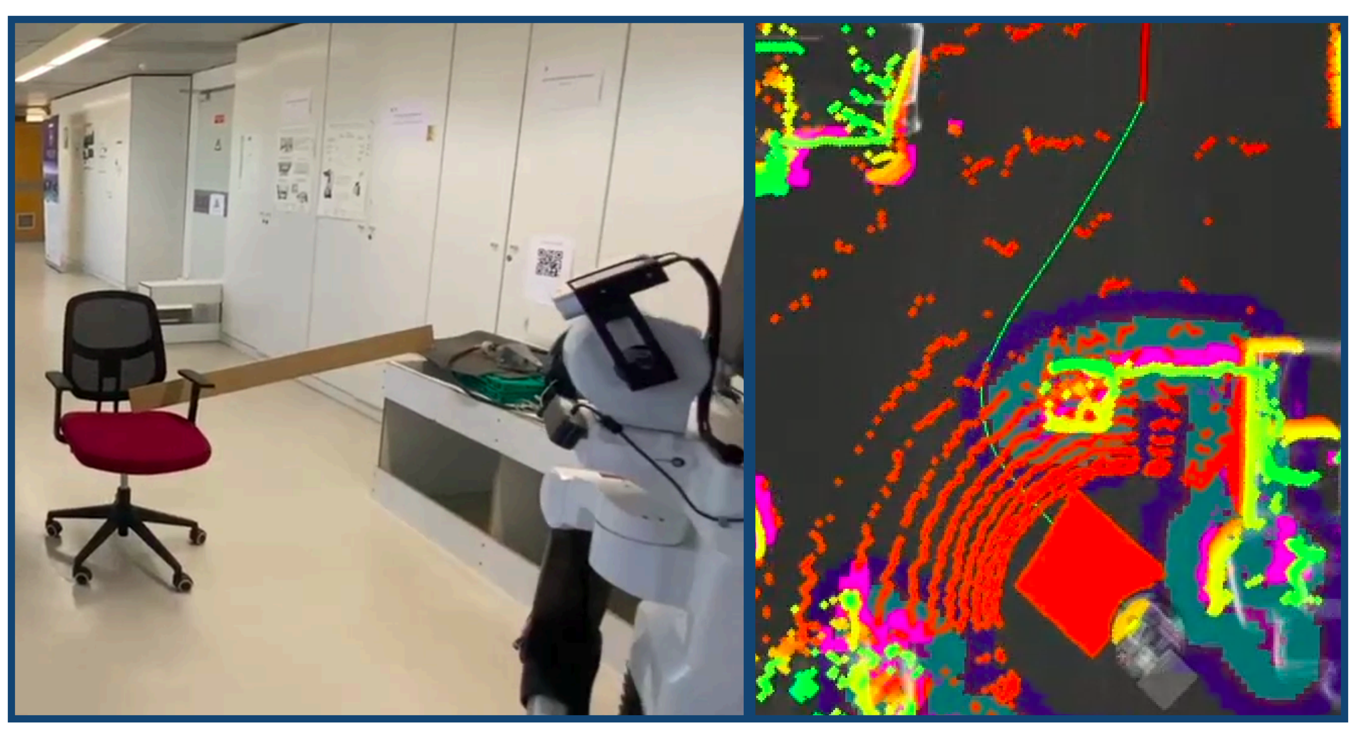


Figure: Left - Real test enrionment; Right - Robot's perception of the environment

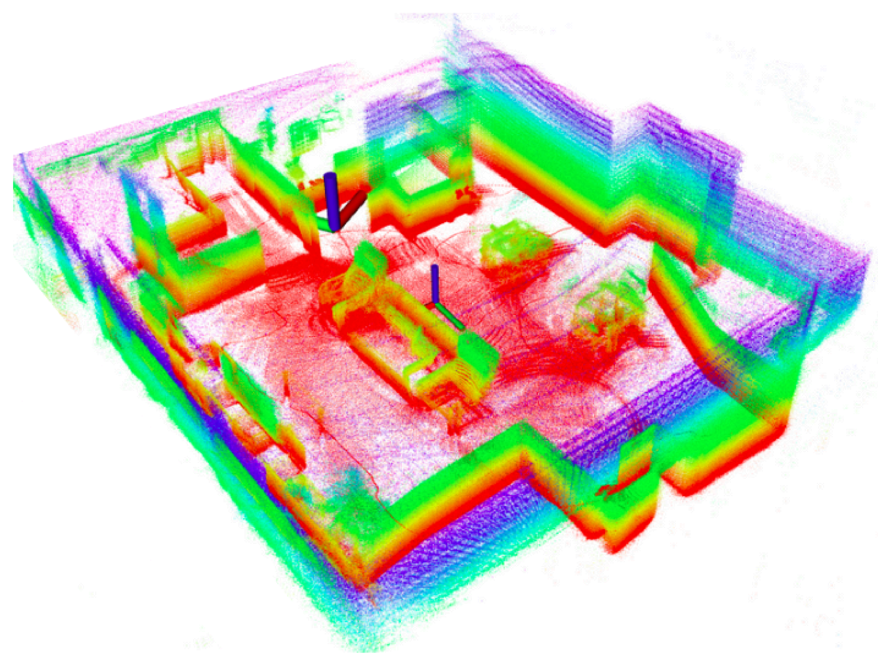


Figure: 3D map of the testbed at ISR

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