D3 Telepresence Robot Mono-SLAM for Remote 3D Mapping

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AUTOPRESENCE
STRESS-FREE AUTOMATION

Abstract

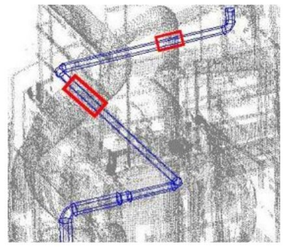
This project aims to **create an affordable physical space 3D mapper through open-source SLAM libraries**.

First step towards relocalization and autonomous navigation for cheaper robots.

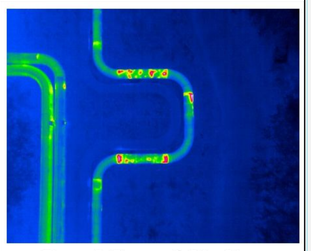
Modular software pipeline can be used on any single-camera robot.

SLAM, combined with thermal imaging, can enable remote access to hazardous work situations, such as in gas leak detection processes.

Parts of Autonomous Gas Leak Detection



3D Point Cloud of Pipeline



Thermal Image of Pipeline

Motivation

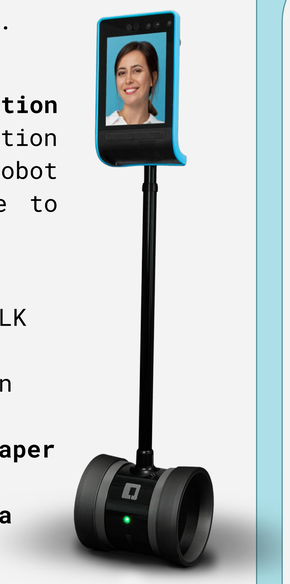
With the recent popularity in autonomous navigation and mapping, and with traditional techniques using LiDAR being expensive. Our project aims to develop a cost-effective, accessible, and reliable mapping system that can be remotely operated and serve as a fundamental tool for various use-cases.

Why SLAM?

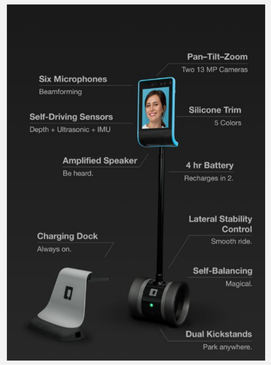
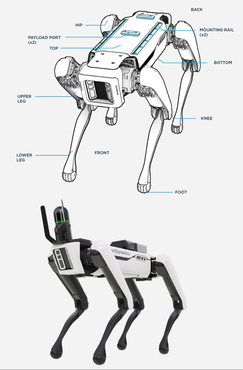
SLAM stands for "Simultaneous Localization and Mapping", which means that in addition to generating a 3D point cloud, the robot will also know its position relative to the environment at all times.

Sponsorship

Boston Dynamics' "Spot" with Leica's BLK ARC currently dominates the market for agile robots responsible for inspection and data collection, but its starting price is $120,500 USD. **To enable a cheaper SLAM solution for the industry, Leica Geosystems sponsored our project with a Double Robotics' Double 3 Robots (D3)**, which was used in combination with Mono-SLAM to create precise point-clouds

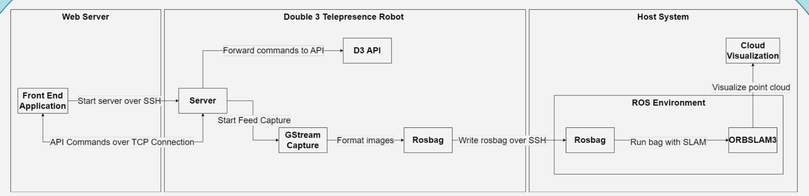


Market Comparison

Double Robotics' D3 + AutoPresence software	Boston Dynamics' "Spot" + Leica's BLK ARC
	
Price Comparison Base Model: **$4,500 USD**	Price Comparison Base Model: **$120,500 USD**
Relevant Features • Semi-autonomous Navigation • Mono-SLAM • Obstacle Avoidance • 3D Data Collection	Relevant Features • Autonomous Navigation • GrandSLAM (LiDAR-SLAM + Visual-SLAM) • Obstacle Avoidance • 3D Data Collection

A <u>data collection</u> aspect (generation and storing of the 3D point clouds of the environment) will be built in the D3 robot through this capstone project of building SLAM. Autonomous driving can also be achieved through SLAM.

Discussion



This modular SLAM pipeline has many applications in the real world, especially in situations where GPS is not reliable or precise enough.

Use Case

Gas leak detection is a process that requires a high degree of spatial precision to ensure worker safety. Combining our product with the use of thermal cameras, we could generate heat maps that overlay in 3D space to aid in the detection of gas leaks and their *exact* locations through relocalization.

Points of Improvement

A point of development from this project would be to add a real-time cloud display to the screen, and shift our pipeline to fully autonomous.

Conclusion

Our product aims to provide a high-quality SLAM solution at a lower cost than industry competitors, making SLAM more accessible to smaller projects or lower budgets.

Methods and Results

The implemented pipeline has four key components: **ROS, OpenCV, ORB-SLAM3,** and a **User Interface**.

The **User Interface** was developed using React (a JavaScript library) to create a modern web application, that enables remote control of the robot from a host computer in addition to starting the SLAM pipeline.

OpenCV is a library of software tools that the team used to stream and refactor image data from the robot's camera.

ROS is a way for different parts of the pipeline to communicate, and is effective in this project due to it being language-neutral. It also allows for storing and calibration of the captured images.

ORB-SLAM3 performs the SLAM algorithm that extracts features from the collected images which are combined to create point clouds in 3D space.