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Robust Vision-Guided Robotic Grasping and Motion Planning in Clutters Using 3D Point Clouds and ROS

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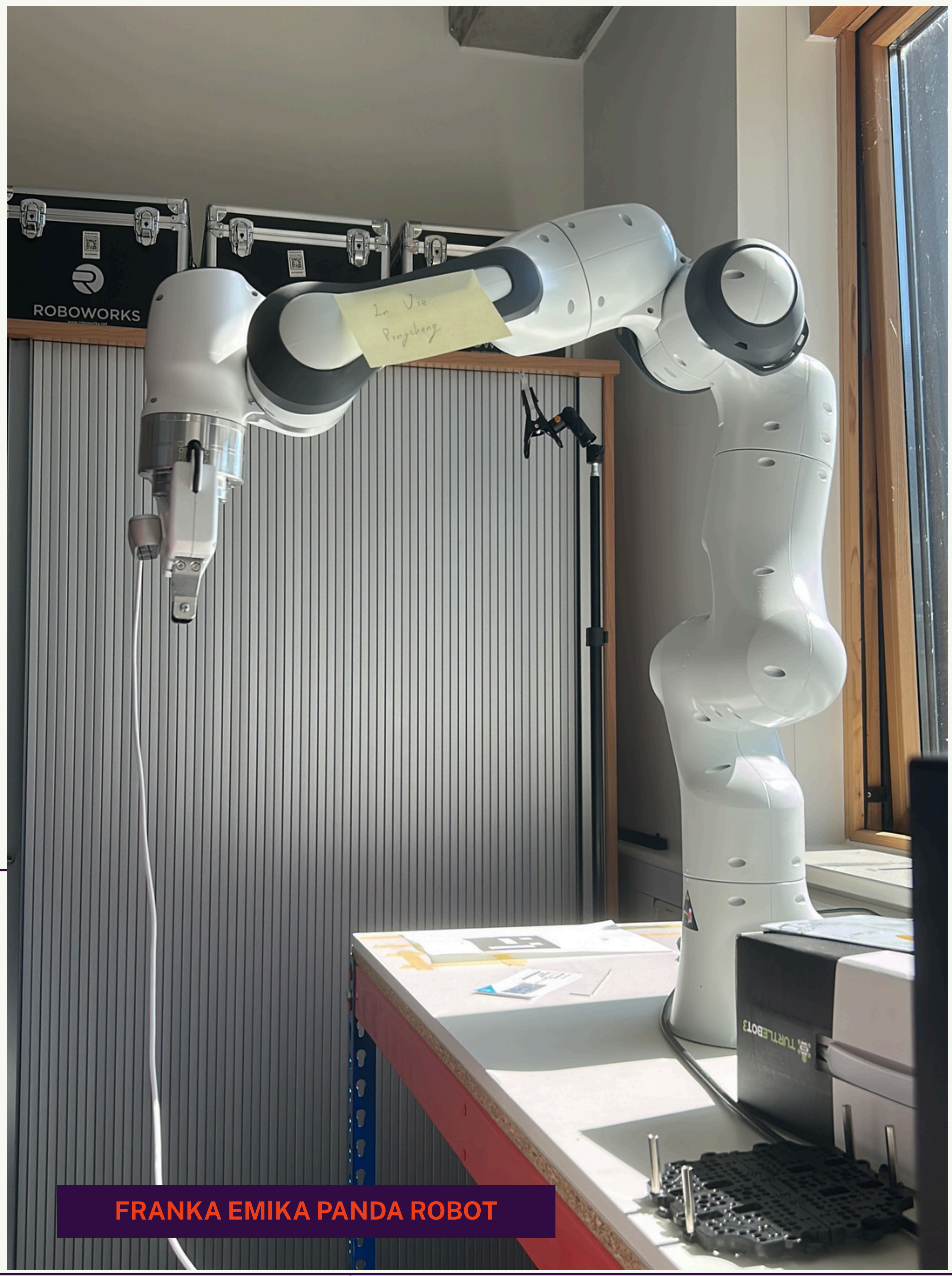


FRANKA EMIKA PANDA ROBOT

INTRODUCTION

The ability of robotic systems to perceive and interact with complex 3D environments is essential for autonomous manipulation tasks. This project investigates how point cloud data can be processed in real time to detect objects and generate feasible grasp poses. We integrate the Franka Emika Panda robot with a perception-driven pipeline using ROS, Gazebo, MoveIt, and RealSense data to perform robust pick-and-place operations in simulation.

METHODOLOGY

Environment Setup

- Developed a simulated environment in Gazebo.
- Integrated Franka Panda robot model with ROS.

Perception Pipeline

- Captured real-time point cloud data using an Intel RealSense camera.
- Applied voxel grid downsampling and statistical outlier removal to reduce noise.
- Performed RANSAC-based plane segmentation to detect and isolate the table surface.
- Extracted individual object clusters using DBSCAN clustering.

Grasp Pose Estimation

- Computed surface normals and centroids of clustered objects.
- Selected grasp candidates using geometric heuristics (e.g., approach vector, surface flatness).
- Exported grasp poses to JSON and published them via ROS on the /pick_pose topic.

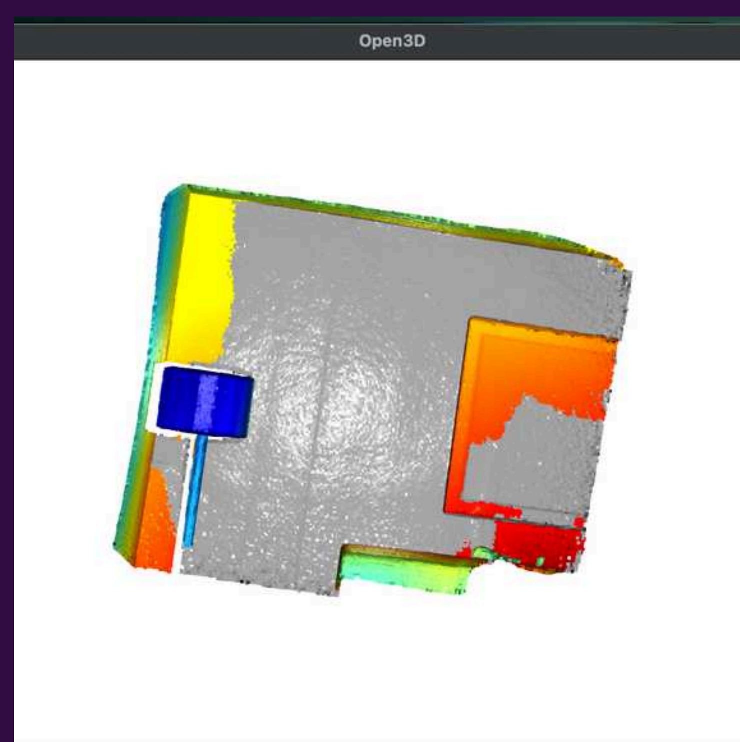
Motion Planning

- Integrated grasp poses into MoveIt to plan pick trajectories.
- Performed TF transformations to align pose frames between the camera and the robot base.
- Ensured collision-free execution of trajectories within the Gazebo simulation environment.

RESULTS

Point Cloud Processing: Real-time filtering and segmentation
Grasp Pose Estimation: Accurate grasp generation
Motion Planning and Execution: Smooth, collision-free trajectories

GRASP POSE VISUALIZATION IN RVIZ.



SEGMENTED POINT CLOUD (DBSCAN + RANSAC).

CONCLUSION

This project demonstrates an integrated vision-guided grasping system using 3D point clouds in ROS. The pipeline successfully segmented objects, estimated feasible grasp poses, and executed motion plans in simulation. Key challenges included frame alignment and robust segmentation. Future work will focus on improving reliability, adapting to dynamic scenes, and deploying on physical hardware.

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