SAND2025-08873C

Sandia National Laboratories

RAM-Stack: A ROS 2 Autonomy Stack for Multi-Agent SLAM and Navigation

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Brigham Young University, April 2026
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I. Overview

This research presents the development of RAM-Stack (ROS Autonomous Multi-Agent Stack), a ROS 2-based autonomy stack for multi-agent systems incorporating components such as Navigation2 (Nav2), SLAM Toolbox, and ROS 2 Control. This system facilitates robust autonomous navigation in both hardware and simulation environments. This integrated approach not only enhances the performance and reliability of autonomous systems but also serves as a versatile framework for future research and development in robotic autonomy.

II. Components

Figure 1 shows the structure of the autonomy stack with the following components:

Motion Commands — Generates desired motion commands as a 3D twist (i.e., linear and angular velocities). The Twist Mux forwards the highest-priority command to the hardware system.

Feedback System — Provides necessary state feedback on velocity and position for closed-loop speed control and mapping.

Hardware System — Translates and executes the desired velocity into motion commands that can be interpreted by the physical hardware, such as applied voltages.

Figure 1: The process diagram for the ROS 2-based autonomy stack

III. ROS 2 Control, SLAM Toolbox, and Nav2

ROS 2 Control converts rigid-body twist commands into wheel velocities based on the vehicle's kinematic model.

SLAM Toolbox creates a map of the previously unknown environment while traversing the area.

Nav2 utilizes the estimated map to generate and command feasible path following while executing dynamic obstacle avoidance.

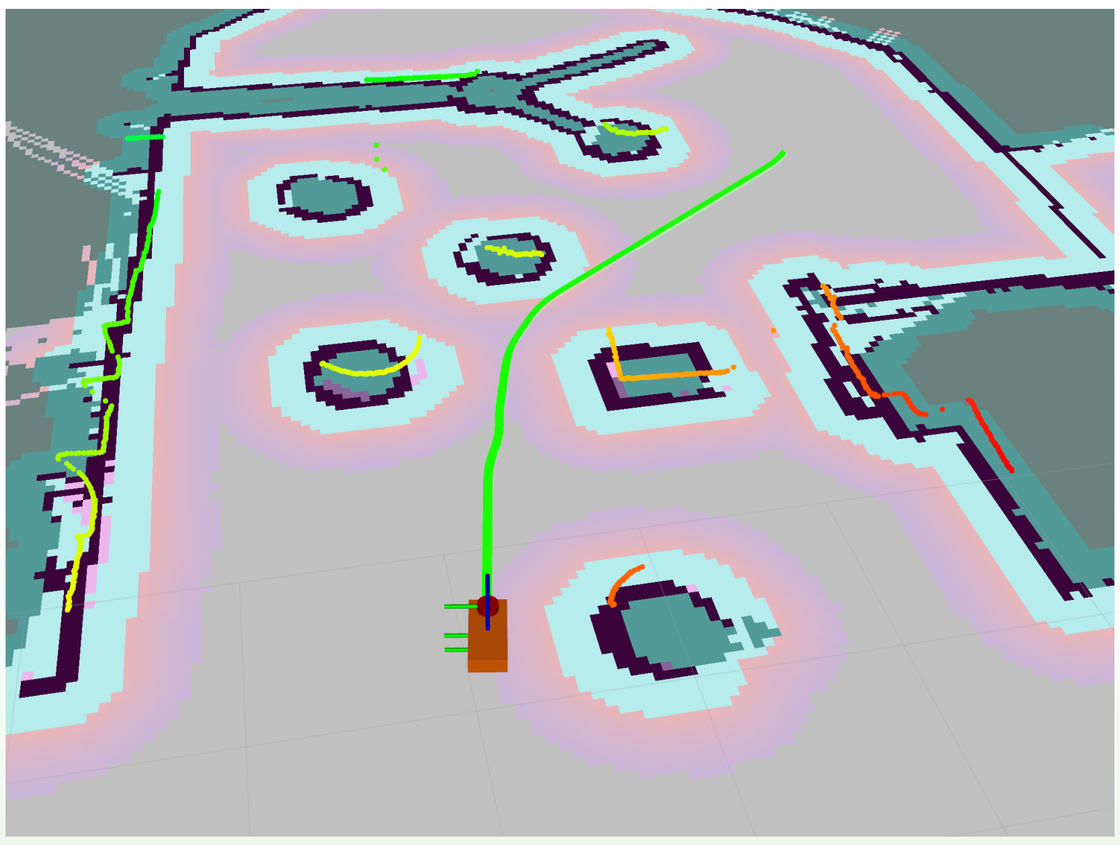

Figure 2: Visualization of our robot (orange) traversing a previously mapped environment along an optimal path (green)

IV. Results and Discussion

Figure 2 illustrates our ground vehicle autonomously following a self-generated path (represented by the green line) using a map created through SLAM in the AutonomyNM high bay. This map effectively identifies multiple obstacles, including boxes and barrels, throughout the environment.

This autonomy stack serves as a robust plug-and-play resource for future research in autonomy, particularly involving diverse multi-agent systems. For example, the SLAM Toolbox can be substituted with a swarm-compliant algorithm. Different vehicles, such as drones, can be seamlessly integrated by adjusting only the ROS 2 Control component. By developing this flexible framework, we aim to facilitate advancements in autonomous systems and pave the way for innovative applications in complex environments.

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