Accelerating Early-Stage Robot Navigation Development with Motion Capture and ROS

Pratik Mukherjee
Department of Ocean and Mechanical Engineering
Florida Atlantic University (FAU)
Boca Raton, FL, USA
pmukherjee@fau.edu

Daniel Granda
Department of Ocean and Mechanical Engineering
Florida Atlantic University (FAU)
Boca Raton, FL, USA
dgranda2022@fau.edu

Vladimir Gunichev
Department of Ocean and Mechanical Engineering
Florida Atlantic University (FAU)
Boca Raton, FL, USA
vgunichev2022@fau.edu

Caleb Sanchez
Department of Ocean and Mechanical Engineering
Florida Atlantic University (FAU)
Boca Raton, FL, USA
calebsanchez2020@fau.edu

***Abstract*—This paper presents and validates a waypoint navigation system that integrates the OptiTrack motion capture system with the Robot Operating System (ROS) Noetic. Utilizing precise positioning data provided by OptiTrack, we demonstrate successful navigation of Clearpath Robotics' Husky A200 robot platform without the need for onboard sensors, relying solely on external camera positioning and odometry data. Waypoints are recorded via a joystick interface, and the robot autonomously navigates these predefined points within a controlled environment. Experimental results confirm that employing an external motion capture system like OptiTrack is an effective strategy for early-stage validation of navigation algorithms and path planning methodologies, significantly reducing complexity and accelerating development by avoiding premature sensor integration. This approach is applicable to various robotic platforms, including unmanned aerial vehicles (UAVs).**

***Index Terms*—robot navigation, ROS, OptiTrack, motion capture, waypoint navigation**

I. Introduction

Developing controllers, navigation stacks, and path planners for autonomous ground vehicles presents considerable challenges, particularly when integrating complex onboard sensors such as LiDAR, cameras, and inertial measurement units (IMUs). Integrating multiple sensor modalities frequently introduces delays and complicates initial testing phases, hindering early validation of critical navigation algorithms.

The OptiTrack motion capture system offers an alternative solution by providing highly accurate, reliable positional data in real-time. By leveraging this external system, developers can test navigation and control algorithms independently of onboard sensors, thus streamlining development and validation processes. This paper explores the feasibility of this approach and demonstrates its effectiveness in accelerating initial system validation. The presented methodology is generalized and can be extended beyond ground vehicles, making it suitable for UAV development as well.

II. Related Work

Previous research has explored various external localization methods for early-stage testing of autonomous navigation systems. Motion capture systems such as Vicon and OptiTrack have been commonly used for precise positional tracking in controlled environments. These systems have demonstrated the ability to provide sub-centimeter accuracy, making them suitable benchmarks for validating algorithms in robotic systems. Moreover, researchers have previously used motion capture systems to validate navigation algorithms for both ground robots and UAVs, significantly reducing integration complexity and testing time.

Other approaches to simplified early-stage testing include using visual markers or beacons; however, these methods often lack the precision and scalability offered by motion capture systems. Studies in the literature consistently highlight the advantages of external tracking systems in rapidly prototyping and iterating autonomous control and navigation strategies.

III. Methodology

The experiments were conducted using the Husky A200 robot, developed by Clearpath Robotics, which provides a flexible and robust navigation framework compatible with ROS Noetic. Our testbed consists of twelve OptiTrack motion capture cameras strategically arranged within a controlled lab environment, providing positional accuracy on the order of millimeters.

Position data obtained from the OptiTrack system is published directly to ROS, allowing the Husky robot to use these external position estimates combined with local odometry from wheel encoders to accurately determine its real-time location. The general workflow involves capturing pose data from OptiTrack, converting it into usable ROS topics, and interacting with the robot using a user-friendly joystick interface. This workflow significantly simplifies initial algorithm testing compared to integrating multiple onboard sensors upfront.

To facilitate waypoint-based navigation, we developed a custom ROS-based waypoint navigation package, inspired by previous open-source work available on GitHub [1]. Waypoints are captured interactively using a PlayStation 4 (PS4) controller integrated within the ROS environment. Once recorded, these waypoints are stored and subsequently processed by a dedicated navigation script, which directs the robot sequentially through each waypoint until the final destination is reached. Experiments were conducted both in a Gazebo simulation environment and within a physical lab setup measuring approximately 30 ft by 15 ft.

IV. Conclusion

Experimental results demonstrated that our waypoint navigation controller effectively guided the Husky A200 robot using only external positioning from the OptiTrack system and local odometry data. The developed testbed environment proved to be a safe, reliable, and efficient platform for initial algorithm validation. By validating the control algorithms without onboard sensors, we significantly reduced integration complexity and accelerated the development timeline. Future work will involve integrating onboard sensors such as LiDAR and cameras to implement simultaneous localization and mapping (SLAM), paving the way for deployment in more complex and realistic scenarios. Additionally, future research under Florida Power & Light (FPL) sponsorship aims to apply our validated navigation methods to power system inspections and monitoring missions. The presented methodology is generalizable and could benefit early-stage development of other robotic systems, including UAVs, further highlighting its practicality and broad applicability.

V. Acknowledgments

FAU, SCUBA LAB, INTECH

References

[1] A. Chatterjee, "GPS waypoint-based autonomous navigation in ROS," GitHub Repository. Available: https://github.com/ArghyaChatterjee/gps-waypoint-based-autonomous-navigation-in-ros.git