From Conventional to Autonomous: A Systematic ROS2-based Framework for Power Wheelchair Control

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INTRODUCTION

Independent mobility is a fundamental human right, yet millions with severe motor disabilities remain without access to it. While powered mobility devices such as power wheelchairs improve quality of life, access control methods such as joystick, sip-and-puff, head control, eye tracking, and brain-computer interface (BCI), may be inadequate for users with conditions such as quadriplegia or amyotrophic lateral sclerosis, especially regarding safety. To address this, we present a systematic ROS2-based framework for converting a conventional power wheelchair into a semi-autonomous platform with sensor-based obstacle avoidance. Unlike prior ROS1[1-2] efforts focused only on hardware integration, this scalable pipeline progresses from simulation to prototype to full-scale wheelchair, ensuring reproducibility and adaptability to clinical and research settings.

MATERIALS AND METHODS

The framework began with Unified Robot Description Format (URDF) modelling of a wheelchair (dimensions: 0.86 × 0.53 × 0.60 m) equipped with virtual sensors on Gazebo. Real-world integration used an RPLIDAR A2M12 and custom ros2_control hardware interfaces for both prototype and full-scale systems. The wheelchair was modelled as a differential drive robot using diff_drive_controller. For the full-scale platform, a relay-based AT-hub directional drive interface bypassed the joystick while preserving the manufacturer's control unit, with high-level commands processed via a Jetson Nano. The prototype used an Arduino Mega with PID speed control. The Nav2 stack was configured for optimal path planning (with theta star) and obstacle avoidance, with tuned costmap, inflation parameters, and footprint settings. The nav2_rotation_shim_controller managed in-place rotations, while the nav2_regulated_pure_pursuit_controller served as the primary navigation controller. Navigation performance was extensively tuned by analyzing RViz outputs, verifying transforms and odometry, and adjusting goal tolerances and inflation scaling to ensure safe, responsive indoor mobility.

RESULTS AND DISCUSSION

The three-stage framework was validated across simulation, prototype, and clinical wheelchair as seen in Figure 1. For a path length of 20.161 m, the full-scale wheelchair achieved a Root Mean Square Error (RMSE) of 0.303 m and a mean error of 0.254 m relative to the planned trajectory. Navigation trials demonstrated accurate path following, responsive in-place rotation, and successful static and dynamic obstacle avoidance in indoor environments despite the inherent dynamics of a relatively large mobility device. However, since odometry was derived from wheel encoders alone, the wheelchair experienced occasional drift, which was temporarily mitigated by system resets. Future work will address this limitation by incorporating sensor fusion of the inertial measurement unit (IMU) and LiDAR for more robust state estimation. Figure 1 shows the progressive development stages of the framework, highlighting reproducibility across simulation, prototype, and clinical wheelchair platforms.

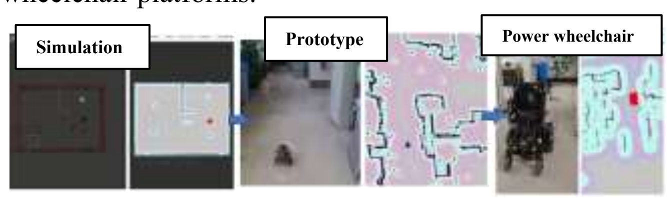

Fig. 1 Systematic developmental framework

CONCLUSIONS

The system successfully enabled autonomous indoor navigation and reliable obstacle avoidance. By establishing a reproducible ROS2-native framework, it lowers the barrier for researchers and clinicians to develop safe autonomous wheelchair systems, ultimately expanding access to mobility for individuals with severe disabilities. These findings establish a robust foundation for the future integration of brain-computer interface (BCI) control, shared control, and intuitive navigation, particularly in pediatric rehabilitation, where accessibility, safety, and adaptability are critical.

REFERENCES

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