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Robotic Applications for Safe Operations in Hospital Isolation Rooms

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***Abstract*—Hospital isolation rooms expose healthcare workers to infection risks during routine tasks like IV bag replacement and material delivery. This paper presents a teleoperated TIAGo robot system controlled via Bluetooth joystick through a modular ROS 2 architecture including five specialized Python nodes to manage robot subsystems. Two Gazebo simulation scenarios validate the approach: IV replacement and meal delivery in modeled hospital rooms, demonstrating feasibility for reducing exposure.**

***Index Terms*—Medical Robots, Isolation Rooms, Teleoperation, ROS 2, Gazebo, TIAGo**

I. Introduction

Robotic systems have been effectively deployed in hospital environments to perform repetitive or high-risk tasks such as transport, disinfection, and patient interaction [1], thereby enhancing safety for medical staff and reducing the usage of personal protective equipment (PPE).

Isolation rooms in hospitals, designed to contain infectious agents, still require frequent human intervention for tasks like IV bag replacement or delivery of meals and medical supplies. Studies conducted during the COVID-19 pandemics [2] highlight that teleoperated robots and mobile manipulators can significantly reduce staff exposure while maintaining the continuity and quality of care.

In this paper we present a proof-of-concept (PoC) for robotic teleoperation in isolation rooms, which leverages a TIAGo robot [3], teleoperated via a Bluetooth-connected joystick, to perform partial IV bag replacement and to transport objects both into and out of an isolation room, thereby reducing the risk for healthcare workers. The TIAGo robot exemplifies a mobile manipulator platform integrating mobility, perception, and manipulation, making it well-suited for assistive roles in healthcare settings.

II. Design

The PoC was developed using ROS 2 [4], specifically ROS 2 Jazzy[1], and the Gazebo simulator [5], specifically Gazebo Harmonic[2].

The simulated environment was built starting from a scaled floor plan of a university hospital department of the Polyclinic of Bari. The structural model in Fig. 1, specifically the walls and layout of the isolation rooms, was custom-built for accuracy. Detailed 3D models of furniture and medical equipment were subsequently added to replicate a realistic hospital scenario.

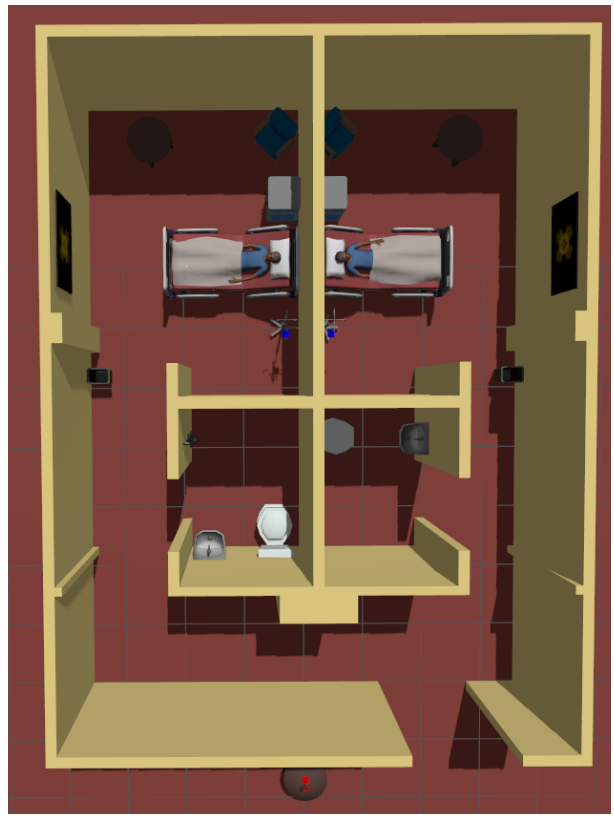

Fig. 1. Isolation rooms modeled in Gazebo.

Teleoperation of the TIAGo robot was implemented using a PS4 joystick connected via Bluetooth, selected for its usability and intuitive control. Bluetooth connectivity was deemed suitable for this application, as the estimated effective range of 13–18 meters comfortably covers the size of the simulated isolation rooms.

The teleoperation system was entirely developed using ROS 2 Python nodes, leveraging the modular architecture provided by the ROS 2 framework. A total of five dedicated nodes were implemented (Fig. 2), each responsible for a specific functionality of the TIAGo robot: base motion, torso elevation, head orientation, arm movement, gripper control.

[1]https://docs.ros.org/en/jazzy/
[2]https://github.com/gazebosim/gz-harmonic

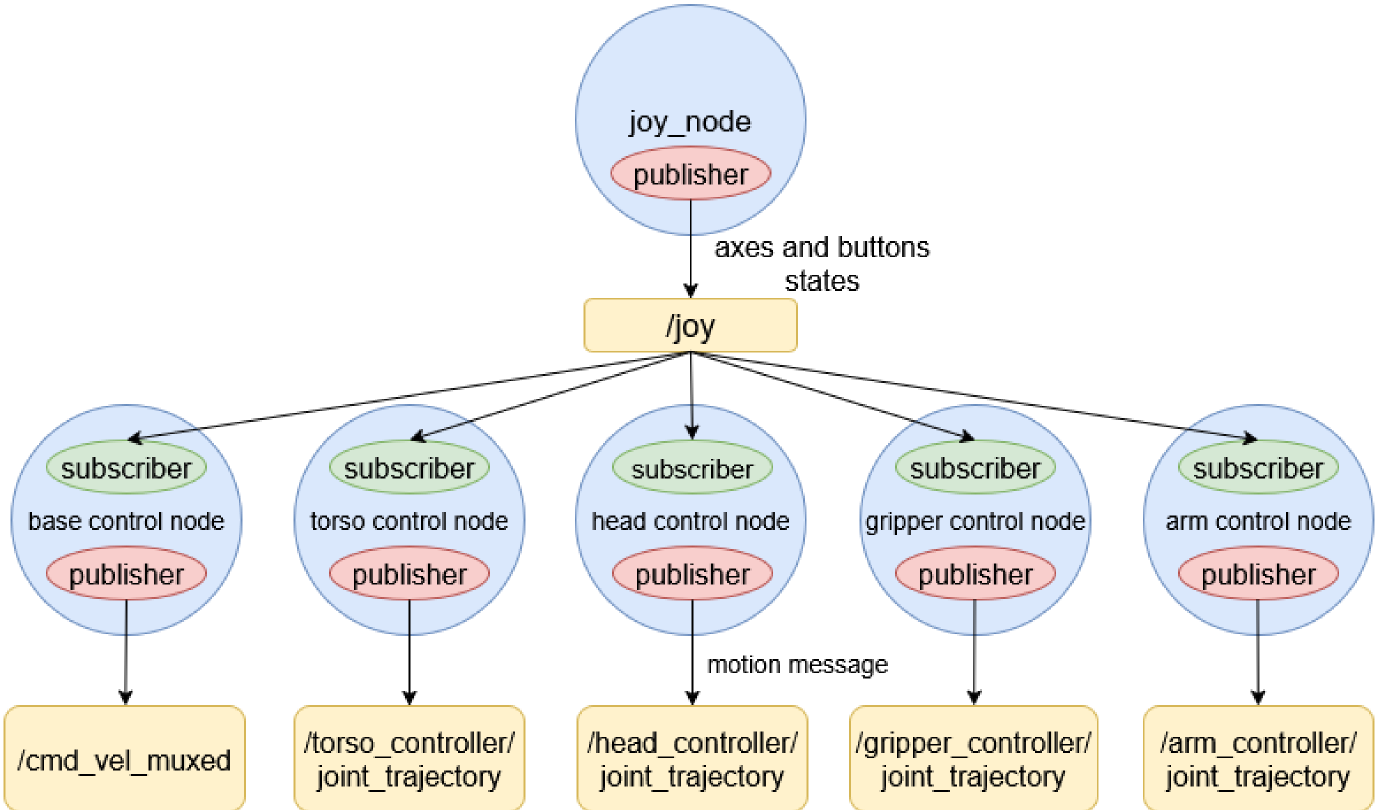

Fig. 2. Modular ROS 2 architecture for the teleoperation of the TIAGo robot.

The core of the system relies on subscribing to the `/joy` topic, which broadcasts joystick inputs using the `sensor_msgs/msg/Joy` message type. Each control node listens to this topic and interprets the relevant joystick signals in real time.

The base control node reads the left analog stick values to generate `Twist` messages, which are published to `/cmd_vel_muxed` to command the robot's wheels, enabling linear and angular motion.

The torso control node handles vertical adjustments via `JointTrajectory` messages sent to `/torso_controller/joint_trajectory`, based on clicks of the analog sticks, ensuring movements stay within the range of 0.0–$0.35\,\mathrm{m}$.

For head control, directional inputs from the D-pad are processed to adjust yaw and pitch via the joints `head_1_joint` and `head_2_joint`, with a cooldown mechanism to prevent multiple activations from a single press. The resulting trajectory is published to `/head_controller/joint_trajectory`.

Similarly, the arm control node maps right analog stick movements and shape button inputs to angular increments across the seven joints of TIAGo's manipulator arm, publishing the appropriate commands to `/arm_controller/joint_trajectory`.

The gripper control node enables open/close commands through the joystick triggers, adjusting the finger joints `gripper_left_finger_joint` and `gripper_right_finger_joint` via the `/gripper_controller/joint_trajectory` topic.

Each node implements safety constraints such as joint limits, dead zones, and time intervals to ensure precise and stable control. This modular node-based architecture not only facilitates clean separation of functionalities, but also enhances maintainability and future scalability of the system.

III. Discussion and Conclusions

The proposed robotic system was evaluated in two distinct simulated scenarios, each targeting a high-risk healthcare task within the context of hospital isolation rooms. In the first scenario, the operator controlled the TIAGo robot to remove a depleted IV bag from a stand and replace it with a new one. In the second scenario, the robot was teleoperated to collect a food tray and deliver it into the isolation room. Both tasks are illustrated in Fig. 3.

The successful execution of both simulated scenarios shows that the proposed solution is technically feasible and can be effectively implemented using the adopted technologies and framework. As a threat to validity, we acknowledge that the IV model used in the simulation is a functional custom-built approximation rather than a realistic replica. This simplified design was intentionally adopted for the PoC, as handling a real IV bag to stabilize the stand while detaching or attaching the bag is an operation that exceeds the capabilities of a single-arm robot. For the same reason, door models were omitted

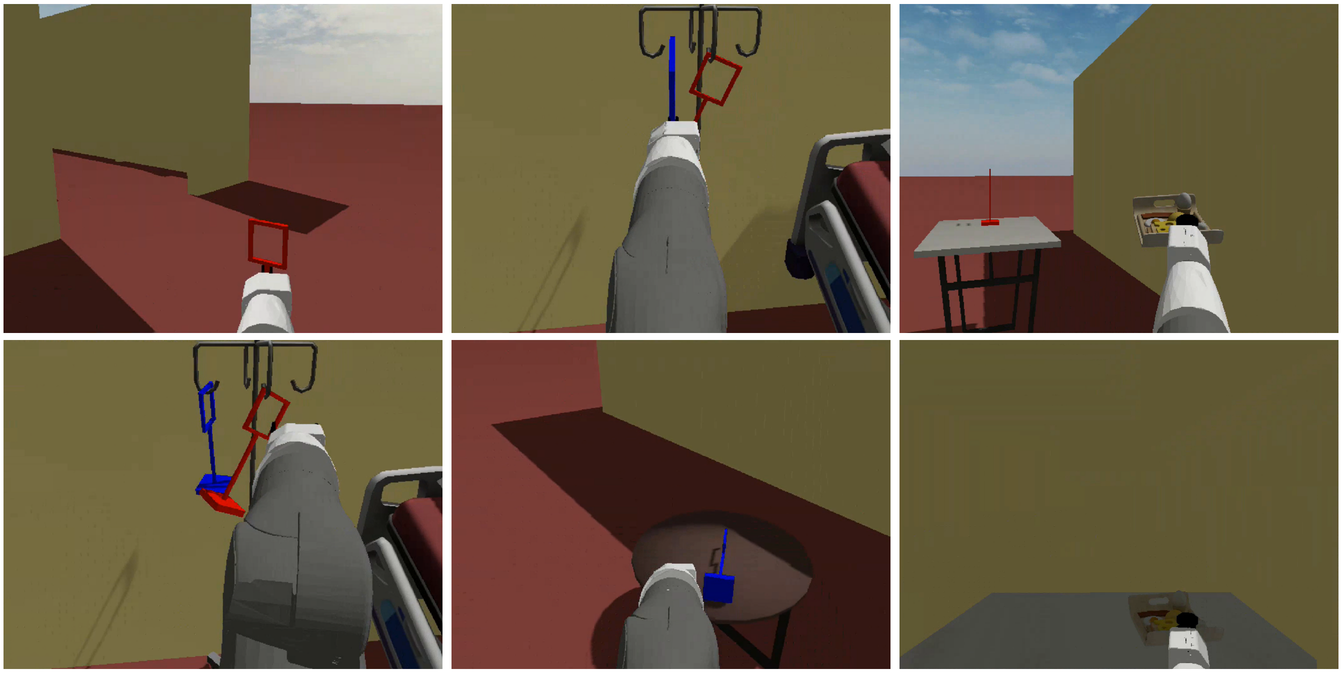

Fig. 3. TIAGo performing IV change and food delivery in simulation.

from the simulation, since a single-arm robot cannot simultaneously carry objects and perform door-opening actions.

The flexible and modular nature of the presented system paves the way for extensions. In particular, a future development involves adopting a robot equipped with a second arm, which would consequently require further adaptations to the joystick interface and the existing control nodes. This modification would significantly expand both the number and the complexity of tasks the robot can perform.

Additionally, the current IV model used in the simulation should be replaced with a more realistic representation that mirrors the geometry and physical properties of actual medical equipment, allowing for more accurate testing.

Finally, another planned improvement concerns the management of audio communication with the patient. Connecting Bluetooth earphones with an integrated microphone directly to the TIAGo robot would make it possible to transmit audio from the operator to the robot's speakers and, vice versa, to stream the audio captured by TIAGo's built-in microphones back to the operator's earphones. This setup would enable a smooth and natural vocal interaction between patient and medical staff.

IV. Acknowledgments

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