A Flexible Clinician-Friendly Interface for Upper Limb Rehabilitation with Industrial Robots

Chiara Alessi[1], **Nikolas Sacchi**[1], **Antonella Ferrara**[1]
1 Department of Electrical, Computer, and Biomedical Engineering, University of Pavia

BACKGROUND

Robotic rehabilitation supports neurological patients by assisting movements and providing objective assessments through sensor-based metrics [1]. The Center Out Point To Point (**CO-PTP**) exercise is widely used to evaluate movement quality and identify areas of motion requiring more effort [2]. **Teaching By Demonstration (TBD)** allows therapists to intuitively program robotic trajectories, enhancing patient interaction in Trajectory Tracking (**TT**) exercise [3].
While specialized medical devices exist, they are costly and less scalable. **Industrial collaborative robots** offer a more affordable and versatile alternative, but their adoption in rehabilitation remains limited [4]. Expanding their use, along with intuitive software and user-friendly Graphic User Interfaces (**GUI**), could improve accessibility and effectiveness in therapy.

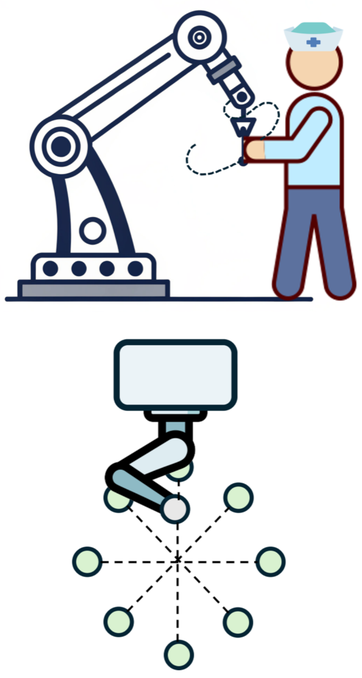


Fig.1- A clinician follows the TBD approach, designing and recording a trajectory moving the end effector of the robot in the 3D space (top). Tthe CO-PTP exercise setup is shown (bottom).

THE PROPOSAL

We propose software for clinicians using industrial collaborative robots in rehabilitation. It collects movement data via ROS2 and features a GUI for intuitive data visualization, allowing clinicians to tailor exercises like CO-PTP and TT based on patient needs. Robots are usually controlled via a manufacturer-provided API, the Robot Control Interface (RCI), which typically uses TCP/IP or UDP but requires complex integration.

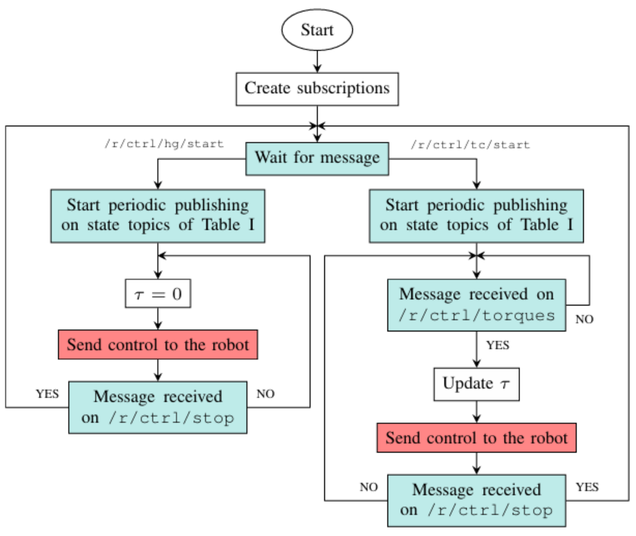
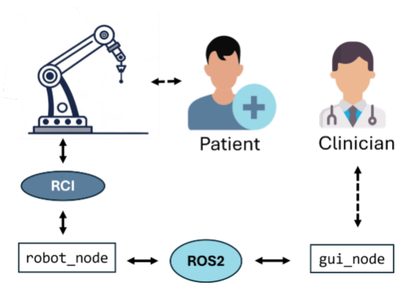


Fig. 2 - A Flowchart of the robot_node structure (top). Graphical representation of the flexible rehabilitation frame work (right).



In the proposed framework, both the robot control and the GUI-based rehabilitation interface are implemented as ROS2 nodes (the **robot_node** and the **gui_node**) to streamline communication. **Gui_node** is preimplemented in Python, while **robot_node** must be adapted for diffe-rent robots but follows the simple development flow-chart shown in Fig. 2.

THE GRAPHICAL USER INTERFACE

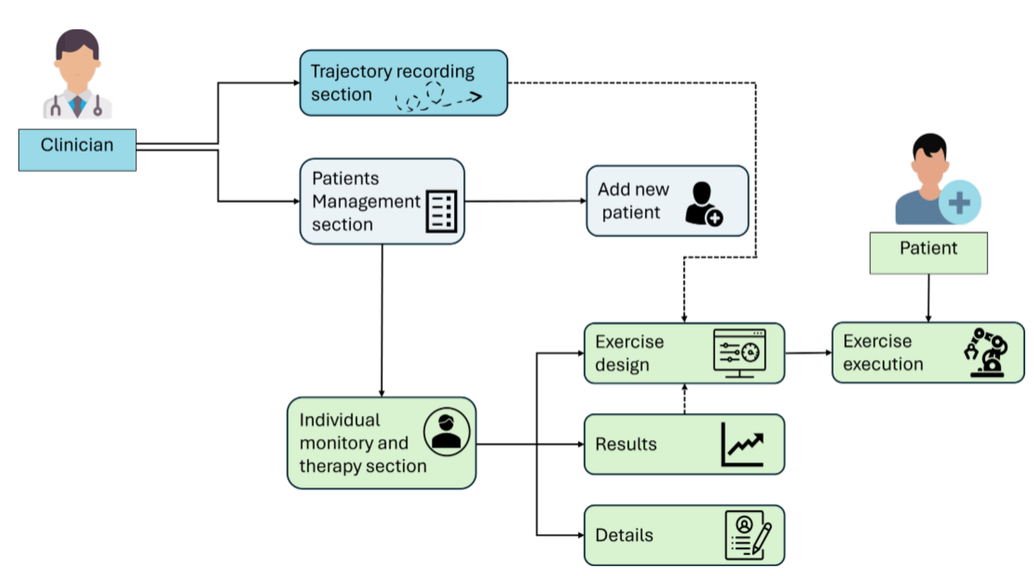


Fig. 4 - Diagram of the GUI architecture



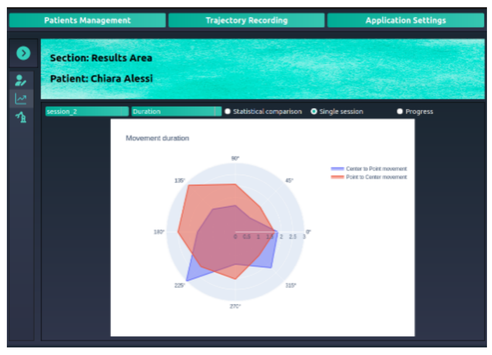


Fig. 5 - Results section screenshots of the GUI.

The graphical interface consists of multiple sections: **Trajectory Recording** for recording movements, **Patients Management** for handling patient data, and **Individual Monitoring and Therapy** for analyzing rehabilitation progress and configuring exercises. During the CO-PTP exercise, key movement metrics are calculated to identify challenging directions, enabling the system to adapt exercises for patient improvement.

EXPERIMENTAL VALIDATION

In order to assess the effectiveness of the software and its compatibility with industrial robots, it was tested in combination with Franka Emika Panda, a collaborative robot characterized by 7 degrees of freedom, demonstrating full compatibility with the software.

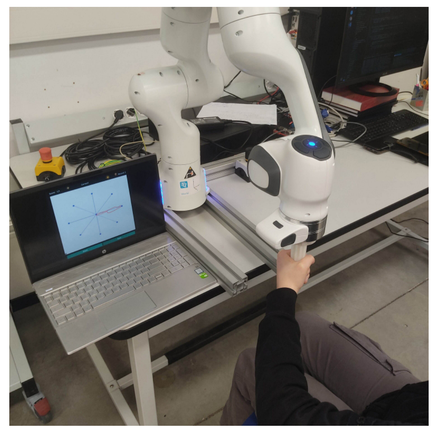


Fig. 6 -Experimental testing of the compatibility of the software with a Franka Emika Panda.

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