PrtBot – Development of a robotic platform for the diagnosis of paratonia

Background

Resistance to passive movemen, or *hypertonia*, is one of the most common physical tests in neurology and psychiatry. Two classical forms are well established: Parkinsonian rigidity (Rgd) and spasticity (Spt). A third type—*paratonia (Prt)*—is probably the most frequent but remains poorly understood and often misdiagnosed against Rgd, leading to inappropriate care [Hobbelen06]. Prt is polymorphic and difficult to describe, typically recognized only through specific manual maneuvers. Recent work in old-age psychiatry and neurogerontology has renewed interest in Prt, now recognized as the most prevalent form of hypertonia in elderly patients [Foucher24, Marinelli22, Schwarzinger22].
A consensus definition [Hobbelen06] describes Prt as: (i) a variable resistance to passive movement, (ii) independent of movement direction, (iii) with a speed dependence distinct from spasticity (no clasp-knife phenomenon, no exaggerated tendon jerks). Two subtypes are identified: *facilitatory Prt,* where patients involuntarily assist the movement, and *oppositional Prt*, where they resist it. Diagnosing Prt may require repetitive and varied passive motions, including unpredictable trajectories or pacing, to reveal these behaviors.

Project Overview

Current diagnostic approaches rely on subjective clinical judgment, which can be unreliable, especially in mixed cases of Prt and Rgd. The **PrtBot project**, conducted by the *Robotics, Data Science and Healthcare Technologies (RDH)* team at ICube (Université de Strasbourg, CNRS), **aims to develop a robotic system capable of performing controlled manipulations of a patient's arm** to acquire objective diagnostic data. The project is hosted on the *IRIS platform (Imagerie, Robotique et Innovation en Santé)* at the *IHU Strasbourg*, and funded by the *HealthTech Institute of Excellence (ITI HealthTech)*. The work lies at the intersection of medical robotics, neurology, and human–robot interaction.

Master's Thesis Objectives

The **Master's work will contribute to the proof-of-concept of the envisioned diagnostic system.** The student will design and integrate the core components enabling safe and effective physical Human-Robot Interaction (pHRI):

1. **Mechanical interface design** — develop the coupling between the robotic arm and the patient's limb;
2. **Sensor data acquisition** — combine measurements from the robot's force/torque sensors, EMG/IMU systems, and kinematic data for subsequent analysis.
3. **Robot control development** — implement and tune pHRI control algorithms, typically variable impedance/admittance control (VIC) for safe motion execution.

The Master's student will benefit from existing equipment at IRIS, including: a KUKA IIWA collaborative robot a multi-axis force/torque sensor**,** an EMG/IMU acquisition system for muscle activity and limb motion tracking.

Beyond technical development, the project also aims to establish safety and design guidelines toward future clinical trials, including inventorying existing safety features and identifying potential risks.

Scientific Originality

To date, no robotic system has been designed for diagnosing paratonia. Existing robotic approaches address limb impedance estimation [Zhang24] or rigidity assessment in Parkinson's disease [Zito18], but none tackle Prt — which is far more complex due to its active, unpredictable nature. Unlike rehabilitation robots (typically exoskeletons), our system uses a serial collaborative manipulator precisely controlling the patient's arm, marking a novel application of medical robotics in neuropsychiatric diagnosis.

[Foucher24] J. Foucher et al., *Schizophrenia Research*, 263 (2024), 66–81.
[Hobbelen06] J. Hobbelen et al., *J. Geriatric Physical Therapy*, 29.2 (2006), 50–56.
[Marinelli22] L. Marinelli et al., *J. Alzheimer's Disease*, 87.3 (2022), 1065–1077.
[Schwarzinger22] M. Schwarzinger & C. Dufouil, *The Lancet Public Health*, 7.2 (2022), e94–e95.
[Zhang24] Y. Zhang et al., *Frontiers in Bioengineering and Biotechnology*, 11 (2024), 1332689.
[Zito18] G. Zito et al., *IEEE EMB*

Supervision and Candidate Profile

The PrtBot team includes: Bernard Bayle, Prof., Medical robotics specialist, former head of the RDH team and ITI HealthTech; Dr. Hassan Omran, Ass. Prof., Specialist in robot control; Benoit Wach, Research Engineer, Expert in robotic system development and programming; Philippe Zanne, Research Engineer, Expert in robotic programming and integration. The project is developed in collaboration with the Department of Psychiatry of Strasbourg University Hospital. We are seeking a **highly motivated Master's or final-year engineering student** with a strong background in **robotics, mechatronics, or control engineering**. The ideal candidate has:

- strong programming skills (e.g., C/C++/Python, ROS is a plus but not required)
- good understanding of control theory and/or mechanical design
- interest in experimental robotics and healthcare applications.

A strong taste for hands-on work and system integration is essential.

On a daily basis, the project will be supervised by Dr. H. Omran (homran@unistra.fr) and Dr. Ph. Zanne (zanne.philippe@unistra.fr). Applications (CV + short motivation statement) should be sent to both supervisors. The project will be conducted at IHU Strasbourg within an interdisciplinary environment that combines robotics, neuroscience, and clinical research. The ideal period would be from February or March to July or August. However, the position is available now.