Internship position on
"Control authority between a human and a robotic telemanipulator"

Environment

The work will be carried out at **IRISA-CNRS in Rennes** as part of the Rainbow team (https://team.inria.fr/rainbow/), which is internationally recognized for its scientific activity as well as for technology transfer experience in the field of shared control, multi-robots, haptics, sensor-based control, visual tracking, and visual servoing.

CNRS is is the largest fundamental science agency in Europe, ranked the second most important global research institution in terms of scientific publications (source: Scimago Institutions Rankings) and the eight most important in terms of innovation (source: Thomson Reuters).

Rennes in a lively city in the north-west part of France, capital of the Britanny region. Located 90 minutes from Paris and less than one hour from the sea, **Rennes was named as the leading French city in Europe for "quality of life"** in 2020 and has the highest satisfaction rate among its inhabitants (source: European Commission).

Topic

In the context of robotic teleoperation, control of the remote robot is often shared between the human user and an autonomous controller [Abbink, David A., 2018]. This sharing of control allows the human operator to benefit from the support of the autonomous system while retaining a certain degree of control over the robot. The autonomous controller can assist the human user by regulating the robot's movements to follow the operator's commands and by performing autonomous actions to optimize the robot's trajectory and task execution more efficiently. Shared control is particularly useful in complex tasks that require high precision or are performed in challenging or dangerous environments.

The resulting motion of the robot is a combination of the user's input and the action of the autonomous controller, which is the result of one or more cost functions defined based on the task to be performed, such as maximizing the distance from workspace boundaries or minimizing the energy required by the robot. In these cases, haptic feedback can be highly beneficial in informing the human user about the actions of the autonomous controller [Abi-Farraj, Firas, et al., 2019; Selvaggio, Mario, et al., 2021]. **Haptic feedback** provides a deeper understanding of the actions taken by the autonomous controller, thereby enhancing the operator's trust in the decisions made by the autonomous system and enabling smoother collaboration between humans and machines. This synergy between the human operator and the autonomous controller improves the overall efficiency of robotic teleoperation and leads to more satisfactory outcomes in task accomplishment.

Indeed, shared control enables to combine the precision of autonomous robotic systems with the cognitive capabilities of human operators. However, **it may be challenging to define how to best share the control of the robotic system in a way that is applicable to different users, tasks, and environments.**

Our objective is to devise a **shared-control approach**, which adapts, relying also on haptic feedback, the allocation of control authority at run-time, according to the current confidence of the autonomous controller and performance of the user. This division is enforced through an input-mixing shared-control method, where the inputs from the automation and the human operator are weighted according to our authority distribution. At the current stage, the proposed technique is validated in a robotic cutting task: the users receive haptic feedback to inform them of the authority distribution in addition to the cutting constraints and the contact forces.

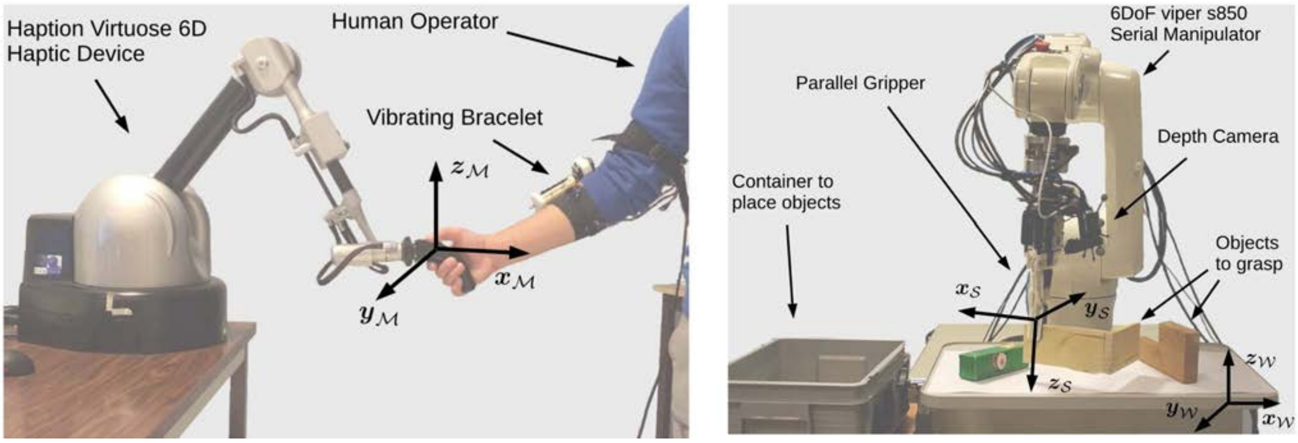

Figure. Example of a teleoperation system with haptic feedback for remote control of a robotic arm. Shared control techniques can help users to manipulate objects more intuitively, safely and effectively, safe and efficient way.

As extension of this work, we would like to analyse the effectiveness of the solution not only in terms of guidance but also for **teaching more complicated tasks**, e.g., how to move in a cluttered environment, as well as compare the proposed mixed-input approach with a haptic shared control method that changes the haptic feedback based on the measured robot and user confidence. The confidence metric introduced in this work can be then tested and validated in other robotic applications, such as drone navigation in cluttered environments.

The proposed workplan consists of

- Orientation and understanding of the problem: analysis and review of the relevant literature to understand the control authority problem in the domain of robot shared-control strategies. (Month 1).
- Preliminary hands-on session: familiarization with the experimental setup, the robotic manipulator arm, the haptic interface and the existing software for the robotic cutting task. First preliminary experiments to collect new data to be analysed (M2).
- Solution enhancement and first experimental campaign: Implementation and validation of possible improvements that could enhance the proposed shared-control solution for the robotic cutting task. (M3).
- Expansion to other robotic applications: investigate how to scale the refined solution to other applications or robot platform (e.g., drone navigation). Analysis and implementation of possible modifications, required to tailor the proposed solution to the targeted application (M4).
- Preliminary validation on the new robotic application: validation, in a simulation environment, of the improved authority allocation technique for the new robotic application, through an experimental campaign (user study). A validation in experimental scenario (e.g., in case of

drone navigation, with the drone platform available in the RAINBOW team) can be also planned (M5).

- Final refinements, data collection and documentation: organize the collected results for analysis. Document the implemented methodology, the provided solution and the deployment in the new robotic application in a final technical report. Writing of a scientific paper(M6).

Requirements

- B.Sc. degree in computer science or related fields;
- Experience in C/C++, Python, robotic control, human-robot interaction is a plus;
- Excellent scientific curiosity, motivation, and ability to work independently.

References

– Melchiorri, Claudio. "Robotic telemanipulation systems: An overview on control aspects." IFAC Proceedings, Volume 36(17), pp. 21-30, IFAC, 2003.
– Hirche, Sandra, and Martin Buss. "Human-oriented control for haptic teleoperation." Proceedings of the IEEE, Volume 100(3), pp. 623-647, IEEE, 2012.
– Abbink, David A., et al. "A topology of shared control systems—finding common ground in diversity." IEEE Transactions on Human-Machine Systems, Volume 48(5), pp. 509-525, IEEE, 2018.
– Selvaggio, Mario, et al. "A shared-control teleoperation architecture for nonprehensile object transportation." IEEE Transactions on Robotics, Volume 38(1), pp. 569-583, IEEE, 2021.
– Abi-Farraj, Firas, et al. "A haptic shared-control architecture for guided multi-target robotic grasping." IEEE Transactions on Haptics, Volume 13(2), pp. 270-285, IEEE, 2019.

Duration

5-6 months

Benefits and Salary

According to French laws (e.g., subsidized meals, partial reimbursement of public transport costs, flexible organization of working hours, insurance).

Advisors and contact

Claudio Pacchierotti
(claudio.pacchierotti@irisa.fr, https://team.inria.fr/rainbow/cpacchierotti)

How to apply

Contact Claudio Pacchierotti at claudio.pacchierotti@irisa.fr, providing Complete Curriculum Vitae (CV), Transcript of record, Short letter of motivation (1 page).