Internship position on
"Optimized time-domain control of teleoperation systems"

Environment

The work will be carried out between the Rainbow group (https://team.inria.fr/rainbow/) of **IRISA-CNRS in Rennes (France)** and the Department of Information Engineering and Mathematics (DIISM, https://www.diism.unisi.it/en) of the **University of Siena (Italy)**. The student can be physically located either in Rennes or in Siena[1].

CNRS 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). The **University of Siena** is one of the oldest and first publicly funded universities in Italy (in 1240). It is ranked as the best middle-sized university in Italy (source: CENSIS).

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). **Siena** is a picturesque city in Tuscany, Italy, known for its medieval architecture and historic center, which is a **UNESCO World Heritage Site**. The city is famous for its annual horse race, the Palio di Siena, and its stunning Gothic cathedral, the Siena Cathedral, which features works by some of the most important Italian artists of the Renaissance period.

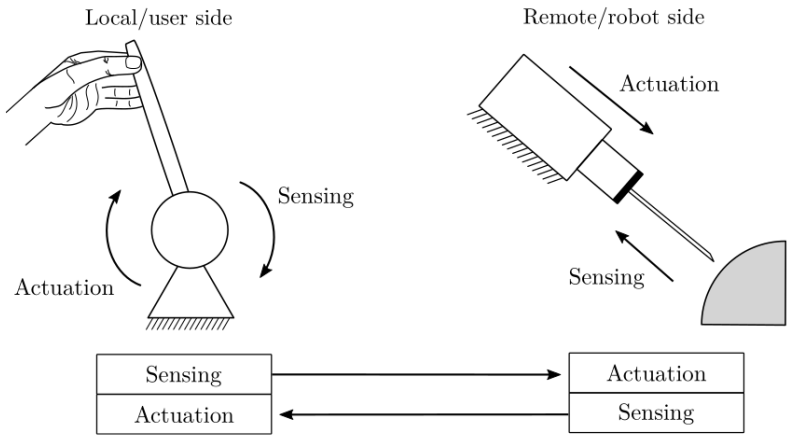
Topic

Control of remote interaction systems with force feedback is of paramount importance both in robotic teleoperation and virtual/augmented reality. Such systems are prone to stability loss due to communication delays and specific features of the teleoperated environment. Time-domain control approaches that leverage passivity theory have proven a flexible and successful tool in designing stabilizing control strategies that do not rely on the knowledge of a model of the environment. In such methods, however, the stability guarantee comes in general at the cost of a reduction of the level of transparency, i.e., of the degree of fidelity in force rendering at both the local and the remote side. Recent research has shown that some degrees of freedom in the design process can be exploited to improve the transparency of a given task under the stability constraint.

The objective of this research work is to **design and evaluate novel time-domain stabilizing control strategies for multidimensional multi-user teleoperation systems**

[1] The place of work will affect a few administrative aspects, including the employer.

aimed at the maximization of the level of transparency by means of online optimization.



(a) Common approach for haptic-enabled teleoperation systems. The force feedback provided to the operator is directly applied at the end-effector of the local device, which is also in charge of controlling the motion of the remote robot. In this situation, a control action is usually needed to avoid unstable behaviors.

The work will address the following points, tuned according on the expertise and interests of the student:

- Theoretical development and simulation of transparency-preserving control strategies based on convex optimization.
- Software development for real-time implementation of the designed methods on real-world teleoperation systems.
- Experimental evaluation and comparison of the performance of the developed control strategies. Design of case studies.

Requirements

- B.Sc. degree in computer science or related fields;
- Experience in C/C++, Unity3D, VR/AR tools, human-robot interaction, convex optimization tools and software libraries is a plus;
- Excellent scientific curiosity, motivation, and ability to work independently.

References

[1] Ryu, Je-Ha, et al. "A survey of haptic control technology." Transactions of the Korean Society of Mechanical Engineers A 33.4 (2009): 283-295.
[2] Franco, Olmo A. Moreno, et al. "Transparency-optimal passivity layer design for time-domain control of multi-dof haptic-enabled teleoperation." 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2018.
[3] Bianchini, Gianni, et al. "Transparency-oriented passivity control design for haptic-enabled teleoperation systems with multiple degrees of freedom." IEEE Conference on Decision and Control (CDC). IEEE, 2018.

Duration
5-6 months

Benefits and Salary
According to French or Italian laws, depending on the place of work agreed with the student.

Advisors and contact
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How to apply
Contact Claudio Pacchierotti and Gianni Bianchini via email (see above), providing

- Complete Curriculum Vitae (CV)
- Transcript of record
- Short letter of motivation (1 page)
- Name of one or two references, e.g., a Professor you worked with.