Introducing OpenPHRI: a software library for physical human-robot interaction

Benjamin Navarro\textsuperscript{1,2}, Aïcha Fonte\textsuperscript{2}, Philippe Fraisse\textsuperscript{1}, Gérard Poisson\textsuperscript{2}, and Andrea Cherubini\textsuperscript{1}

\textsuperscript{1} LIRMM CNRS-UM, 161 Rue Ada, 34090 Montpellier, France.
\textsuperscript{2} PRISME Laboratory, University of Orléans, 12, Rue de Blois, 45067 Orleans, France.

OpenPHRI is a C++/Python software with several built-in safety measures, designed to ease robot programming for physical human-robot interaction (pHRI) and collaboration (pHRC). Aside from providing common functionalities, the library can be easily customized and enhanced, thanks to the project's open source nature. The library is distributed online\textsuperscript{1} free of charge under the GNU LGPLv3 license\textsuperscript{2}.

OpenPHRI is written in C++ to maximize efficiency in terms of computation and memory footprint and to easily embed it in existing projects. Python bindings are also provided, since this language is largely used in the robotics community. An interface with the robotics simulator V-REP\textsuperscript{3} is also provided.

The framework consists in a two-layer damping controller depicted in figure 1. Damping control is a particular case of impedance control [1], which makes the robot act as a mass-spring-damper system. Although impedance control proved useful for complying with interaction forces while following a predefined trajectory, it can be extended to fit many more scenarios. We design a more generic controller that includes real or virtual force inputs and velocity inputs. In this work, the focus has been on:

- real forces exchanged with the human or environment,
- virtual mass and stiffness forces (generating inertial and elastic effects),
- virtual forces repelling away from obstacles,
- velocities generated by a trajectory generator,
- velocities output by a force controller.

To reduce the velocity in unsafe situations, we add constraints, that determine the value of a velocity scaling factor. If multiple constraints are active at the same time, the most restrictive one, i.e. the one leading to the lowest velocity, will be chosen. This makes sure that all the constraints are satisfied at any given time.

The experiment setup is illustrated in figure 2. In less than 35 lines of code one can set up a V-REP scenario where a serial manipulator robot Kuka LWR4+ is moved with an external force applied, while limiting its velocity, reading sensory input, and sending joint commands to the simulator. See Fig. 2 and video available at: http://bit.do/openphrivideo

For further details on OpenPHRI, the reader should refer to [2].

ACKNOWLEDGMENTS

This work has been supported by the ANR (French National Research Agency) SISCob project ANR-14-CE27-0016.

REFERENCES