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# Learning impedance modulation for physical interaction: Insights from humans and advances in robotics

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## Abstract

At the moment, robots are mainly employed for industrial applications where accurate positioning and precise tracking are needed. This led to the development of robotic systems that were stiff and heavy. As such, they can only operate in highly structured environments void of any physical interaction with humans. This limitation has motivated the robotic research community to develop novel theoretical and technological solutions to allow robots to operate amongst and with humans and to safely move in unknown and unstructured environments. To guarantee human safety, the stability and integrity of the robot must be preserved during physical interaction. A common approach is to introduce a certain degree of compliance to the robot, which allows it to account for external disturbances. Compliance can be embedded in robots either passively or actively. For instance, passive visco-elastic elements can be integrated into the robot design. Alternatively, a controller can shape the mechanical impedance of the robot (e.g., stiffness, damping, inertia). This means robot behavior can be planned not only in the kinematic domain (i.e. motion planning) but also in terms of its dynamic response. These approaches have been proven effective in managing physical interaction with its surrounding environment and humans. Still, knowing what the desired robot compliance should be for a given scenario is an open problem. The primary goal of this full-day workshop is to critically discuss the current and new approaches used to identify the proper robot compliance for a given task, interaction, level of uncertainty, etc. We invited speakers to discuss how the selection of impedance parameters can be formulated as an optimization problem, as well as speakers who use learning strategies to understand and generalize task-specific impedance regulation. We have also invited speakers from the human motor control community to discuss how humans are able to robustly manage physical interaction by modulating their mechanical impedance.

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