Torque feedback based impedance control: Theory, performance, and comparison with admittance control

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Abstract—This talk covers three aspects of impedance control for humanoid robots. First a framework for torque feedback based impedance control is presented. The theoretical basis as well as practical design issues are discussed. Secondly, the torque feedback based impedance control concept is compared to admittance control based on end-effector force/torque measurement. Advantages and limitations of both approaches will be discussed. Additionally, a novel concept of a unified impedance/admittance controller is presented. The material of the talk will be exemplified by several applications including two-handed manipulation tasks performed with the DLR’s humanoid upper body robot Justin.

OVERVIEW

Many modern control approaches for robot manipulators assume that the joint torque can be directly commanded via the motors of the robot’s joints. In this way, underlying actuator dynamics is neglected. In practice, the performance and sensitivity of these controllers is often affected heavily by friction and flexibility in the drive units. Joint level torque sensing and control is an effective countermeasure against these problems as has successfully been demonstrated, e.g., in the DLR light weight robots [1], [2] and the Sarcos humanoid robot [3].

In this talk, we discuss how inner loop torque sensing can be incorporated in a passivity based control framework for impedance control ([4], [5], Fig. 1). We highlight the robustness and performance properties of this control approach and show several practical applications.

Additionally, we give a comparison of torque feedback based impedance control with state of the art admittance based controllers. For admittance based control, in particular the consequences of using force/torque sensors which are not located at the relevant point of interaction, but at the base, are discussed. It is shown that the force measurement at the base poses some limitations on the achievable impedance dynamics.

In addition to the comparison of impedance and admittance based approaches, we present an overview of a novel control approach, in which the benefits of impedance and admittance based design approaches are combined [6]. Rather than using a controller with fixed causality, the proposed framework incorporates classical impedance and admittance control as two extreme cases of one hybrid controller.

REFERENCES