Lab Session 4: Admittance Control

1 - Compliant Control: Admittance and Impedance Control

Compliant controllers regulate the impedance level of the human-exoskeleton system by modifying the dynamic relation between velocity and force using virtual elements like springs, dampers or masses (see Eq.1). Two dual control approaches reach this objective: **1. impedance** and **2. admittance control**. The main difference between admittance and impedance control is that the first one controls motion after a force is measured **(impedance)**, and the other one controls force after a motion from a set-point is measured **(admittance)** (see Fig.1 for details). The transfer function $G(s) = \frac{y(s)}{u(s)}$, where $y(s)$ is the output and $u(s)$ is the input in the Laplace domain for the admittance and impedance models, are described in Eq.2 and Eq.3, respectively.

$$F = J(\ddot{q}_{eq} - \ddot{q}) + B(\dot{q}_{eq} - \dot{q}) + K(q_{eq} - q) \qquad \textit{Eq. 1}$$

$$\frac{q(s)}{F(s)} = \frac{1}{Js^2 + Bs + K} \qquad \textit{Eq. 2}$$

$$\frac{F(s)}{q(s)} = Js^2 + Bs + K \qquad \textit{Eq. 3}$$

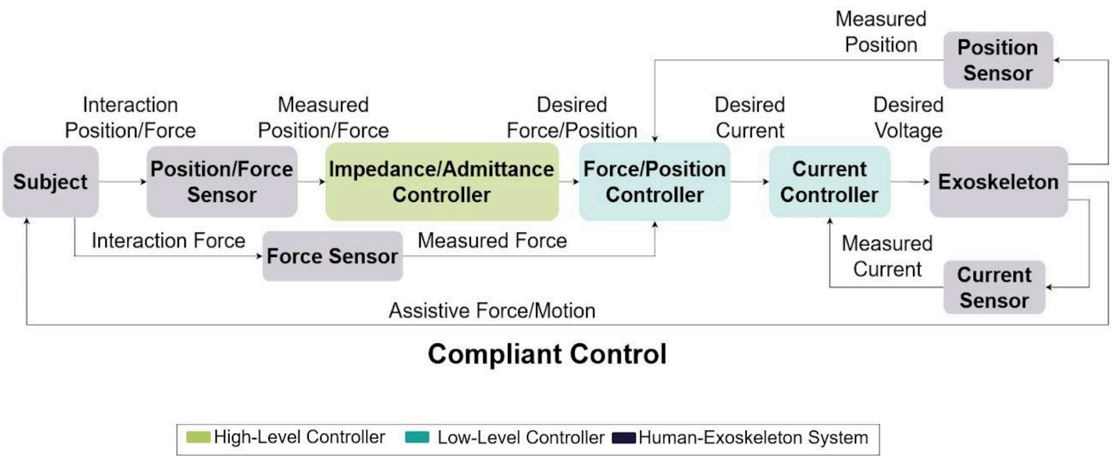

Fig. 1. Control Scheme of the Compliant Control.

The selection between admittance or impedance control will be determined by the mechanical characteristics of the device and the goal pursued. In impedance control, first, the user wearing the device needs to create a positional displacement for the control to work. In impedance control, the device should be low-weight, backdrivable, and can be controlled using a fast and precise current controller. If these specifications are not satisfied, it will lead to a disturbing feeling of the remaining parasitic dynamics and friction effects of the device itself. In contrast to impedance, a precise admittance control will impose its virtual dynamics over the system dynamics, removing the effect of the friction. Thus, admittance control applications are more dedicated to larger non-backdrivable and high-friction devices, since this control strategy presents a stable behaviour toward the displayed high stiffness.

2 - Force Sensor Calibration and Offset Correction

Exercise 2.1 - Get the regression line which associates ADC values obtained from the sensor with force applied to the force sensor in Newtons. Apply different weights in both directions to the load cell.

3 - Admittance Control

Exercise 3.1 - Implement the admittance model in the function ReferenceGenerator(). Remember to reset position and velocity every time the limits are overpassed.

Exercise 3.2 - Create your admittance model around an equilibrium position, vary the admittance parameters and comment the results.

Exercise 3.3 - Find the parameters that make the devices transparent (lower interaction forces). Compare different parameters and show plots.

The code for this lab activity can be found in the zip file available in ATENeA.