Passivity-based Control of Physical Systems

Energy is one of the fundamental concepts in science and engineering practice, where it is common to view dynamical systems as energy-transformation devices. This perspective is particularly useful in studying complex nonlinear hybrid systems by decomposing them into simpler subsystems which, upon interconnection, add up their energies to determine the full system's behavior. The action of a controller may be also understood in energy terms as another dynamical system—typically implemented in a computer-interconnected with the process—to modify its behavior. The control problem can then be recast as designing a dynamical system and an interconnection pattern such that the overall energy function takes the desired form. This "energy-shaping" approach is the essence of the controller design technique—known as passivity-based control (PBC)—that is introduced in this seminar.

Our objectives in this talk are threefold. First, to call attention to the fact that PBC hinges on the fundamental (and universal) property of energy conservation, hence is (in principle) applicable to all physical systems. Second, to provide the basic tools for its utilization on several physical systems. Third, to illustrate with some modern control applications how the use of energy concepts in PBC theory fosters collaboration with specialists from other disciplines, making the incorporation of process prior knowledge more systematic and providing a lingua franca for communication.