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Distinguished Seminar in Robotics, Systems and Control pt.2

Creation and Model-Based Control of Soft Robots Tackling Manipulation and Locomotion Challenges

The seminar was about an approach to robotics different from the classic “rigid robotics”; soft robotics aims at reproducing the continuous deformation of nature by exploiting mechanical materials similar to living tissues. Using fluid-powered soft actuators, it was possible to mimic the fluid motion of a fish. The various soft structures that constitute the actuator, placed in the tail, are inflated and deflated. A single pump pressurizes the hydraulic chambers to provoke motion: by symmetric pressurization the robotic fish moves forward, while by asymmetric pressurization it turns left and right. The fish has a camera on board used to capture pictures and make controlling decisions. The fish was an attempt to build an observatory module that could spy on other species. Another application of soft robotics are soft hands able to distinguish among different objects. The strength sensors on the surface records the forces applied in holding a specific object and through simple clustering models it’s possible to recognize the object. This applications are extremely hard to model: they require a huge state space, it’s then necessary to perform model-order reduction (linearization). Linearizing a model makes it not very reliable under deformation behavior. The solution was fund in combining the rigid robot dynamics (which embodies a rich literature in how to model and control), and soft robotics partial differential equations. To do so, it’s necessary to map each soft state to the corresponding rigid states namely subdivide the soft surface into constant curvature elements. There are some drawbacks in this approach: the rigid model has no dissipative or elastic components which have much importance in the soft robotics world. Those components are added to the equation of the dynamics of the rigid robot together with the actuation force (PCC model). Simulation show that soft robots are able to grasp objects, but very slowly. To increase the speed and account for the uncertainties of the PCC model, dynamic modelling and closed loop curvature controllers are exploited. Some of the observed results are that the robots are able to remain fully straight even though their softness and applying a spring and pushing the arm on a surface, the arm is able to keep on exploring an object by applying the same impedance.