Master thesis proposal

Modeling and Parameter Identification of Soft Objects

Background

Robotic tasks often involve contacts between the robotic end-effectors and various environments. Robotic hands grasping soft objects and tools grasped by robots interacting with deformable surfaces are fundamental tasks in many robotic applications such as robot-assisted surgery, elastic parts robotic-assembly, fruit robotic-collection, food robotic manipulation. Real-time estimates of the environment dynamics are very important in order to design controllers for stable interaction between robotic manipulators and unknown object/environments. Learning of unknown “environments” can be addressed either by using “physics-based” models or machine learning approaches and particularly Artificial Neural Networks (ANN) that become popular particularly the last decade by utilizing Deep Neural Network (DNN) structures.

Problem description

Consider the following setup: a soft object located on a table and immobilized by the use of fixtures. The robot end-effector is applying forces on the object and haptic data that consists of forces and positions/velocities are collected. The general purpose is to derive models that can output the exerted forces when the inputs are the position and the velocity of the robots. In a subsequent phase the learnt model will be used in order to design policies to explicitly control the force exerted on the object.

Purpose and aims

In this Master we will investigate and compare “physics-based” modeling approaches and machine learning for haptic perception (perception that is related to the “hand”). To this aim we will consider the problem of learning soft object models. The learnt models will also be assessed regarding their applicability for real-time force control problems.

The objectives of the project are summarized below:
• Study of the different models for deformable objects and focus on viscoelastic object models
• Design a “physics-based” system identification module for learning the parameters of the viscoelastic model
• Develop an ANN approach for modeling the object
• Use the model in order to design a controller for tracking time-varying force profiles (force-tracking)

The experimental setup will use a UR10 robot controlled through velocity and equipped with a force/torque sensor.

We are searching for two highly motivated students from the master program in Systems, Control and Mechatronics or with a similar background. Knowledge in Modeling and Control of Mechatronic Systems, Neural Networks (Deep Learning) and Nonlinear Systems is required. Knowledge of System Identification techniques is a plus. Programming using Python (or C++) and ROS will be preferred and thus some experience with these tools is a plus.

The master student will build competences within Robotics, Contact modelling, System Identification and Robot Learning and Control. The students will work in the PCL lab at Chalmers.

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