Announcing the Final Examination of Zhangchi Ding for the degree of Doctor of Philosophy

Time & Location: August 1, 2019 at 9:30 AM in HEC 450
Title: NONLINEAR CONTROL SYNTHESIS FOR FACILITATION OF HUMAN-ROBOT INTERACTION

Human-robot interaction is an important problem in robotics in general but especially for assistive robots. Users with disabilities not only need an adaptive interface to interact with their environments but they also require physical human-robot interaction to facilitate their daily living and gain independence.

In this dissertation, three human-robot interaction problem are studied. The first problem considered is that of making a safe compliant contact between a human and an assistive robot. Users with disabilities have a need to utilize their assistive robots for physical interaction during activities such as hair-grooming, scratching, face-sponging, etc. Specifically, we propose a hybrid force/velocity/attitude control for our physical human-robot interaction system which is based on measurements from a force/torque sensor mounted on the robot wrist. While automatically aligning the end-effector surface with the unknown environmental (human) surface, a desired commanded force is applied in the normal direction while following desired velocity commands in the tangential directions. A Lyapunov based stability analysis is provided to prove both convergence as well as passivity of the interaction to ensure both performance and safety. Simulation and experimental results verify the performance and robustness of the proposed impedance controller in the presence of dynamic uncertainties as well as safety compliance of human-robot interactions for a redundant robot manipulator.

The second problem considered is the 1-click safe grasping of novel objects. We propose an intelligent algorithm for adapting the grasping force for novel objects. The use of object-geometry free modeling coupled with utilization of interaction force and slip velocity measurements allows for the design of an adaptive backstepping controller that is shown to be asymptotically stable via a Lyapunov-based analysis. Experiments with multiple objects using a prototype gripper with embedded sensing show that the proposed scheme is able to effectively immobilize novel objects within the gripper fingers.

In the final part, we design and implement the second generation of the UCF MANUS assistive robot system. This includes robot hardware and software architecture as well as the control design for novel object retrieval and safe grasping.

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Approved for distribution by Aman Behal, Committee Chair, on July 16, 2019.

The public is welcome to attend.