



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS**

Name of the Student : Mohamed Abbas

Roll Number : 186103022

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Thesis Title:

Event-Triggered Adaptive Position-Force Control of Robotic Manipulators in Medical and Cooperative Industrial Applications

Name of Thesis Supervisor(s) : Prof. Santosha K. Dwivedy

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SHORT ABSTRACT

Motivated by human dexterity and coordination, robotic manipulators have drawn the attention of researchers in recent years. These manipulators can mimic the human manipulation property and provide assistance at improved accuracies far exceeding those of human operators. Therefore, the adoption of robotic manipulators is demanded in diverse medical and industrial scenarios to fulfill several tasks such as ultrasound scans, rehabilitation exercises, and cooperative manipulation. On the other hand, networked control systems (NCSs) have become very popular in the last few years, introducing several benefits such as flexibility, reliability, and ease of maintenance for practical robotic applications. However, the implementation of such communication poses different constraints, including limited bandwidth channels. Moreover, parametric uncertainties and interaction forces are crucial to consider in the human-robot and robot-environment interaction tasks. Therefore, designing an appropriate controller to achieve the desired position and force tracking for robotic manipulators under the network-induced limited bandwidth, parametric uncertainties, and interaction forces is challenging and open to research. This thesis proposes a few simultaneous position-force control schemes to overcome the aforementioned challenges and maintain the performance and stability of the robotic manipulators in different medical and cooperative industrial applications.

The first part of the thesis is primarily dedicated to designing event-triggered simultaneous position-force controllers for single robotic manipulators in different medical applications, i.e., ultrasound examination and passive and active-assist rehabilitation exercises. The first study presents an event-triggered adaptive hybrid position-force control (ETAHPFC) scheme for the ultrasound manipulator to perform a transversal abdomen scan. In the second study, the event-triggered adaptive backstepping admittance control (ETABAC) scheme is devised to address the uncertainties, limited communication, and patient-robot interaction challenges during the upper limb rehabilitation exercises. In the second part of the thesis, the ETAHPFC and ETABAC are further extended for the framework of cooperative manipulators to tackle the parametric uncertainties in the models of the object and manipulators, environmental interaction, and limited communication constraints. In addition to simulation and comparison results, the experimental validation of the proposed event-triggered adaptive control schemes is conducted for two scenarios, i.e., upper-limb passive rehabilitation training for different subjects and cooperative manipulation of a common object. From the experimental results, the proposed control schemes are found to achieve a promising tracking performance and substantial saving of channel bandwidth in the presence of parametric uncertainties, which confirms the suitability of the theoretical propositions for practical network-based applications.