

USMAN AHMAD

**BSc (Electronic Engineering), The Islamia University of Bahawalpur,
Bahawalpur, Pakistan, 2011**

**MSc (Electrical Engineering), University of Engineering and
Technology, Taxila, Pakistan, 2013**

DEPARTMENT OF MECHANICAL ENGINEERING

**TITLE OF
THESIS:** NOVEL MULTILATERAL TELEOPERATION
AND COOPERATIVE CONTROL
APPROACHES FOR MULTIPLE
MANIPULATORS

TIME/DATE: 9:00 am, Friday, December 7, 2018

PLACE: Room 430, The Goldberg Computer Science
Building, 6050 University Avenue

EXAMINING COMMITTEE:

Dr. Rickey Dubay, Department of Mechanical Engineering, University of
New Brunswick (External Examiner)

Dr. Mohamed E. El-Hawary, Department of Electrical and Computer
Engineering, Dalhousie University (Reader)

Dr. Andrew Warkentin, Department of Mechanical Engineering, Dalhousie
University (Reader)

Dr. Ya-Jun Pan, Department of Mechanical Engineering, Dalhousie
University (Supervisor)

**DEPARTMENTAL
REPRESENTATIVE:** Dr. Darrel Doman, Department of Mechanical
Engineering, Dalhousie University

CHAIR: Dr. Stephen Bearne, PhD Defence Panel,
Faculty of Graduate Studies

ABSTRACT

Teleoperation of robotic manipulators has been one of the popular research areas in the robotics research community for last couple of decades. A variety of control methods have been proposed for bilateral and multilateral teleoperation of robotic manipulators. Although a lot of research has been carried out on teleoperation control, some of the aspects of these systems are still unexplored. For example, most of the control schemes for teleoperation systems focus only on the compensation of time delays while there exist other performance metrics for these systems such as better transparency, optimal force distribution and authority adjustment in cooperative applications. Additionally, some of the control schemes lack to provide the guaranteed stability of the teleoperation system. This research works aims to propose novel teleoperation and cooperative control schemes for fixed-base and mobile manipulators. This research work can be divided into two main parts. The first part of this thesis is focused on the development of a Time Domain Passivity Control (TDPC) scheme which ensures the stability of the multilateral teleoperation system under constant and varying time delays. The proposed control framework not only avoids the zero division problem of the control laws of traditional TDPC but also provides a novel communication channel architecture to assign weights to master and slave robots to cooperatively execute the task. Simulation and experimental results validate the efficacy of the proposed TDPC scheme for the multilateral teleoperation of fixed-base robotic manipulators. The second part is focused on the cooperative and teleoperation control of mobile manipulators. A couple of novel cooperative control schemes have been proposed for the cooperative control of mobile manipulators to manipulate a common object attached to the end-effectors. An adaptive robust teleoperation control scheme has also been proposed with the control objectives of guaranteed stability, synchronization and internal force distribution. Simulation results validate the efficacy of the proposed schemes for the cooperative control and teleoperation of mobile manipulators.