Paper ID: 9589
oral
student

14th HUMAN EXPLORATION OF THE MOON AND MARS SYMPOSIUM (A5)
Joint session on Human and Robotic Partnerships to Realize Space Exploration Goals (3.-B3.6)

Author: Dr. Tamas Haidegger
Budapest University of Technology and Economics, Hungary, haidegger@gmail.com

Dr. Levente Kovács
Budapest University of Technology and Economics, Hungary, lkovacs@iit.bme.hu
Prof. Radu-Emil Precup
Politehnica University of Timisoara, Romania, radu.precup@aut.upt.ro
Dr. Balázs Benyó
Budapest University of Technology and Economics, Hungary, bbenyo@iit.bme.hu
Prof. Zoltán Benyó
Budapest University of Technology and Economics, Hungary, benyo@iit.bme.hu

ENABLING CONTROL TECHNOLOGIES FOR TELESURGERY

Abstract

Human space exploration was given a new boost by targeting again the Moon and the Mars. Besides the USA, China, India and Russia all announced their progressive plans to put astronauts on orbit and beyond in the next decades. The continuous development of robotic technology should lead to the advancement of automated technology, including space medicine. Telesurgery has already proved its effectiveness through various procedures on Earth, and it has the potential to support medical assistance in space. NASA and other agencies have already performed a significant number of experiments and developed various setups to push the boundaries of teleoperation. Different control schemes have been developed and tested to facilitate and enhance telepresence and to ensure transparency, bandwidth and latency-tolerance . This paper is focusing on a novel concept using classical control options to provide a simple, universal and scalable solution for the challenges of telesurgery over large distances. We propose a cascade controller structure supported by Kessler's design method in order to handle varying latency. In the case of a cascade structure, the data of the inner loop gives feedback to the outer loop, but no a priori knowledge about the inner loop's dynamics is required to design the outer controller. On the other hand, it is possible to explicitly consider the remote dynamics in the outer controller in order to predict the inner behavior. This can be based on the well-known Smith predictor, or similar schemes. This is a crucial and effective observation, as in the case of teleoperating a robot on board of a spacecraft, significant delays can appear in the control loop. The control commands given to a robot-simulator are sent to the remote robot using a time-delay network. Consequently, the ground workstation contains a model of the uplink and the downlink delays as well as a model of the actual states of the real robot and its environment. The key of the setup is to accurately model the surgical environment, therefore a realistic and valid virtual reality can be displayed to the physician. With adaptive motion scaling of the robot and blending of the augmented reality with the continuous sensory information update, an ergonomic surgical working environment can be created. In our simulations, the proposed structure was capable of providing acceptable control parameters up to 2 seconds of delay. The proposed cascade loop may be a good solution to support future teleoperational missions.