

**VIBRATION SUPPRESSION OF BILATERAL TELE-
OPERATION WITH VIRTUAL IMPEDANCE
CONTROLLER**

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of Science of Engineering

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

September 2014

DECLARATION

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I endorse the declaration by the candidate

Dr. A.M.Harsha S.Abeykoon

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ABSTRACT

Bilateral tele- operation is one of a major part in robotics as well as in motion control. Most of the researchers have done experiments on bilateral tele-operation but still they haven't given much attention on vibration suppression of bilateral tele-operation even though it's important on latest technology. This research is mainly focuses on vibration suppression of bilateral control system. Initially a frequency response analysis is done to the bilateral control system to identify the natural frequency of the system. PD controller parameters, motor inertia, force coefficient and disturbance observer filter coefficient values are varied to identified the parameter effect of the system. By varying the parameter values cutoff frequency can be shifted to the left side. Those analyses depicts that the conventional bilateral control system has the capability to suppress vibrations up to some certain extent.

Further suppression can be done by moving the cutoff frequency point to the left side while reducing the frequency bandwidth. This can be done by adding filters to the system. Bilateral control system mainly focuses on force and position responses of master and slave. So that slave environment vibrations can be reflected to the master side in both forms of position and force. System was tested with adding a position filter, force filter and finally the both filters. Vibrations of the system cannot be suppressed by using a position filter. Because its' differing master and slave force response magnitudes. Above analysis was done by using the available hardware unit. According to the simulation and practical results of modified system with force filters gives good results and the cutoff frequency point is slightly shifted to the left side. But by adding filters to the system main equations of the convention bilateral control system are violated.

New concept of virtual impedance controller is introduced to the system as another vibration suppression method. Rigid link in between master and slave is replaced by an impedance controller. This system also behaves as a bilateral control system but the force and position are controlled independently one after another. Through a frequency response analysis natural frequency of the new system is identified. Internal and external vibrations can be suppressed by changing the parameters of the virtual impedance controller along with PD controller parameters. Compared to the frequency responses of the conventional bilateral control system the modified system with virtual impedance controller frequency responses has a lower cutoff frequency value. Then the parameter effect is analyzed for the system with virtual impedance controller. By varying the PD parameters, spring coefficient and damping coefficient values, system cutoff frequency point can be adjusted. So that the unwanted vibrations of a bilateral control system can be suppressed by using the above method. The above analysis was verified with simulation results and practical results.

Keywords: bilateral control, disturbance observer, vibration suppression, frequency responses, virtual impedance controller

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