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Master thesis

Application of adaptive haptic assistance in bilateral shared controlled teleoperation tasks with sensorless human force estimation

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Telerobotics is a special case of human-robot interaction, where a robot (slave robot) is remotely controlled by a human operator via a control device (master robot) [1]. Telerobotics is used in tasks that humans cannot perform on their own (e.g. micromanipulation), or which take place in dangerous environments (e.g. handling radioactive material). In bilateral telerobotics, the human operator not only sends commands to the slave robot, but also receives information from it. Such information is for example contact force between the slave robot and objects in its environment, which then is displayed haptically at the operator's site. Shared control permits the human operator, as well as the slave robot, to modify motion trajectories during task execution. Thus, bilateral shared control is used when assisting the human operator during a teleoperation task. A common way of assistance is the use of virtual fixtures, which are virtual elements in the slave robot environment that help the user to follow a desired path or prevent him/her from entering restricted areas. A rather young field of research is the use of adaptive assistance in telerobotics, where the properties of virtual fixtures are changed depending on the behavior of the human operator. In contrast to constant (structured) assistance, the user benefits from a high flexibility in unforeseen situations during the task execution (e.g. unknown obstacles on the desired path).

In this work, the adaptive assistance proposed in [2] will be applied and evaluated in a virtual teleoperation setup. However, a limiting issue is the lack of information about the force exerted by the human operator on the master robot, which is necessary for the adaptive assistance. Due to the lack of force sensors in the master robot, the human force has to be estimated. A possible way for such an estimation is proposed in [3], but also other approaches exist. Furthermore, a comparison of the proposed setup under different parameter configurations for the adaptive assistance in form of a user study is presented in this work.

The thesis consists of the following tasks:

- Creation of a virtual telerobotic setup
- Sensorless estimation of human force on the haptic control device
- Implementation of the adaptive assistance in the telerobotic setup
- Execution of a user study with different parameters for the adaptive assistance
- Documentation and presentation

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References:

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[3] A. Gupta and M. K. O'Malley, "Disturbance-Observer-Based Force Estimation for Haptic Feedback," *Journal of Dynamic Systems, Measurement*, and Control, vol. 133, no. 1, pp. 014505-1-014505-4, 2011.