2013 IEEE/RSJ International Conference on
Intelligent Robots and Systems (IROS)
November 3-7, 2013. Tokyo, Japan

Virtual Reality Support for Teleoperation Using Online Grasp Planning

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Classic telepresence approaches allow a human to interact with a remote or a virtual reality environment (VR) with force feedback. Coupling with a remote robot can be used to work in dangerous environments without the human being on-site. The coupling with a VR system can be used for training and verification of task sequences or robotic actions.

We present an enhanced telepresence system that uses the advantages of VR to perform manipulation tasks in remote environments with multifingered hands. It provides the user with an intuitive interface that visualizes the knowledge of the robot about its environment; and the combination of VR, telepresence and shared autonomy facilitates object manipulation for the user.

The VR is the central system component combining and distributing all information of the other components, providing a visualization for the operator, and enabling shared autonomy features, see Fig. 1.

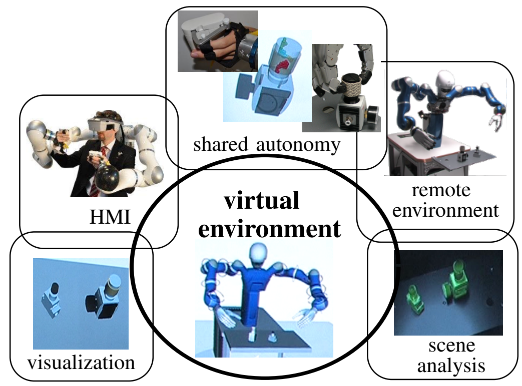

Fig. 1. Conceptual scheme of the enhanced telepresence system using shared autonomy

The user is coupled to the DLR Light Weight Robot arms of the HMI [1]. The position-force coupling with the remote robot allows the operator to command movements and to experience realistic force feedback on his palms. Additionally, he controls a one degree of freedom force feedback device with his fingers, that displays the grasping forces and enables to adjust the grasp force depending on the task. The operator sees a combined 3D visualization of the remote and the virtual environment. The visualization uses interactive features for robot viewers [2] which provide important information about the remote robot (e.g. applied torques) intuitively, and presents results of the shared autonomy features. The remote robot is a modified version of DLR's humanoid robot Justin [3] with two DLR-HIT Hands II [4] used to interact with the environment.

The basis for shared autonomy is the scene analysis that provides information about which objects are in the remote environment and where they are. Here, a sequential analysis framework [5] that is able to keep track of the changes to the remote scene over time is employed. Due to the expected lack of texture information in telepresence scenarios, the object recognition module of the framework is based on dense depth images, as produced by, e.g. stereo camera systems [6] or Kinect-like sensors. Specifically, a geometric matching approach [7], that was extended by a fast GPU based verification step, is used.

The provided shared autonomy feature is online grasp planning: robust force closure grasps are calculated online based on the relative position between hand and object provided by the operator. Taking the workspace of the robotic hand into account, currently reachable points on the objects are calculated. When an initial force closure grasp is found, reachable independent contact regions [8] are grown and the user can grasp the object by closing his fingers. Otherwise, the visualization suggests a new thumb position to get a force closure grasp.

Initial experiments have shown that the VR environment used in a shared autonomy approach leads to a more robust execution of tasks with a reduction in the cognitive load for the operator, especially for object manipulation. More elaborate user tests are ongoing work.

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