Immersive ROS-integrated Framework for Robot Teleoperation

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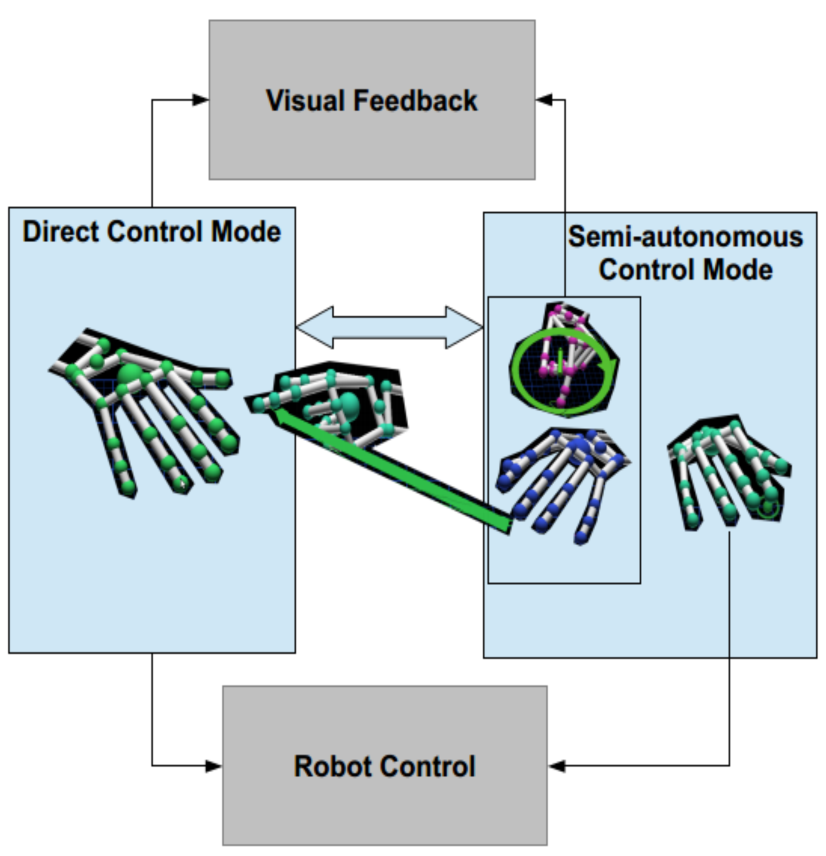
We present a ROS-integrated interface for remote control. The user teleoperates the robot using hands motion. Robot autonomy can be adjusted online between two levels: **direct control** and **waypoint following**. The **Leap Motion** is employed to generate the control commands. The user receives a real-time 3D augmented visual feedback using a Kinect sensor and a HMD.

Context and Goal:

- In robot manipulation human cognitive abilities are still needed in complex scenarios.
- With no time delay **direct teleoperation** has been proved to be the most effective approach [1].
- **Fully autonomous** behaviors are less effective, but do not suffer from time delay sensitivity [1].
- The proposed system provides the user with two different autonomy levels selectable online during the task execution.
- Body-based teleoperation and a high level of embodiment are provided since they improve user's dexterity [2].



•**Direct control**: a position control is implemented using the human right hand pose and closure as a reference.

•**Shared control**: the user can freely move his right hand and define waypoints for the robot arm using the *Keytap gesture*. *Moveit!* grasp planning node plans and executes a trajectory for the robot arm.

•The user is also able to explore the visual feedback scene with left hand movements.

•**A new framework for high-performance AR/VR** (**CoCo**), based on components has been created.

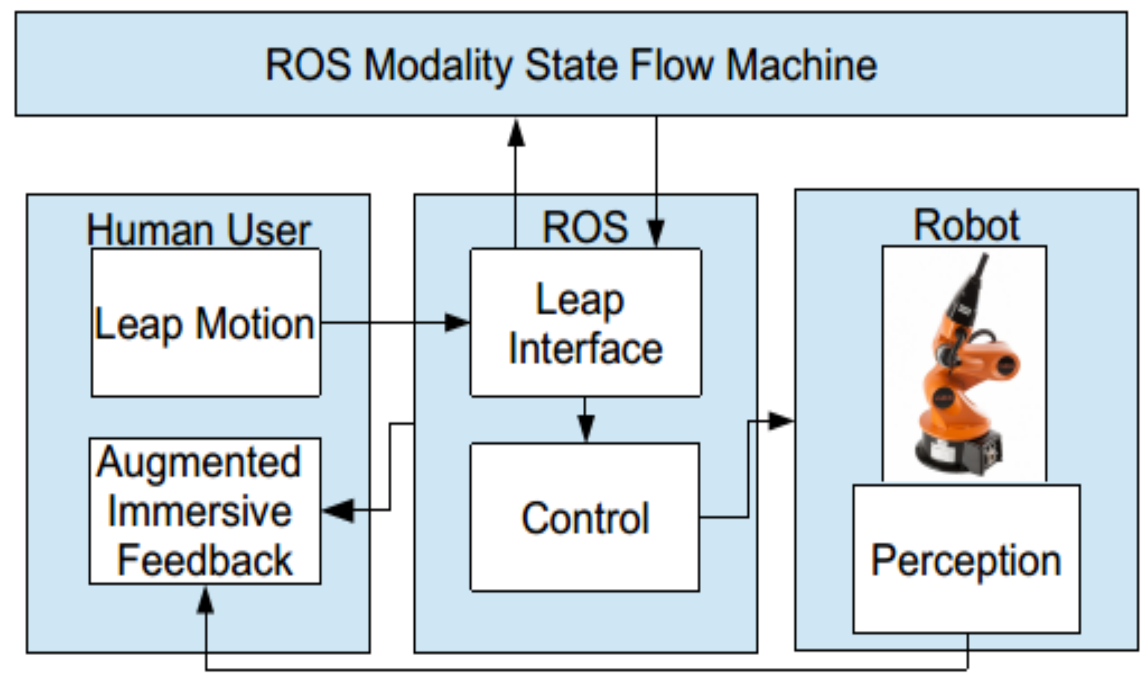
Streams decompression → **Interpolated PC** → **AR Rendering (30 Hz, 60 Hz virtual objects)**

Conclusions

We presented **a ROS integrated framework for robotic platforms teleoperation with adjustable autonomy**.

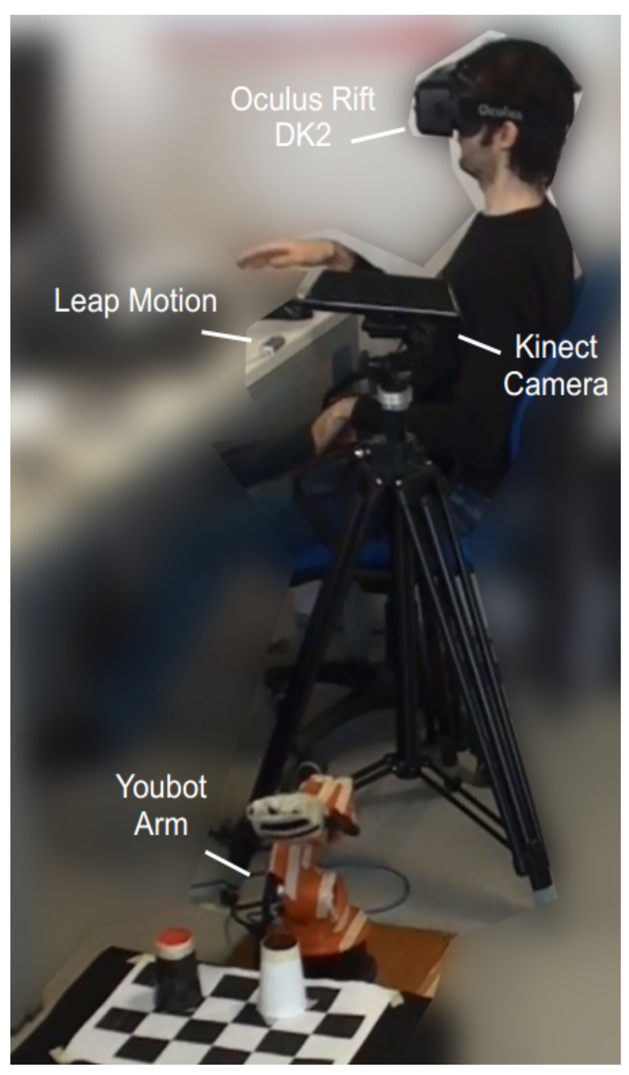
- The human-robot interface is gestures-based.
- A 3D augmented visual feedback of the environment on the remote robot side is given to the user through a Kinect camera and an HMD.
- The system performances have been assessed using a KUKA Youbot arm. Manipulation tasks can be successfully carried out with the current system.
- The performance is influenced by the workspace and the dexterity of the teleoperated arm.
- Issues remain about workspace matching between robot and user.

The System Architecture



The ROS Leap Interface exposes data from the Leap Motion device in ROS. The information about hands reference frames, gestures and closures are used by ROS both to switch control mode (by the Modality State Flow Machine) and to control the robot in both the modes (by the ROS Control Node). The perceptual stream from the remote robot side is sent back to the user's side for the augmented immersive feedback. The feedback is augmented with information about hands positions and waypoints coming from the ROS control node and the ROS Leap Interface.

Experimental Setup



To assess the performance of the system we performed several tests switching between the two control modalities.

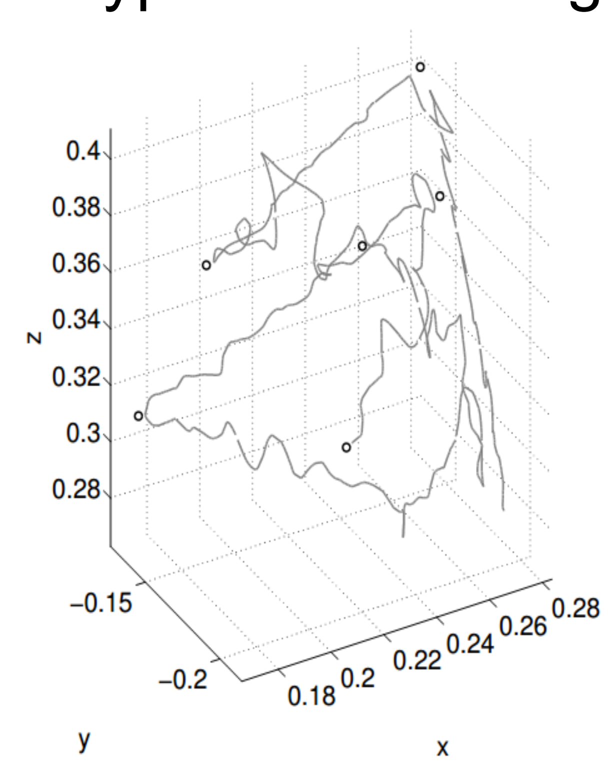
Two different phases:

1. The user was asked to move the robot end effector in the direct control mode touching two different spots.
2. The user has been asked to define several series of waypoints though which the robot had to move.

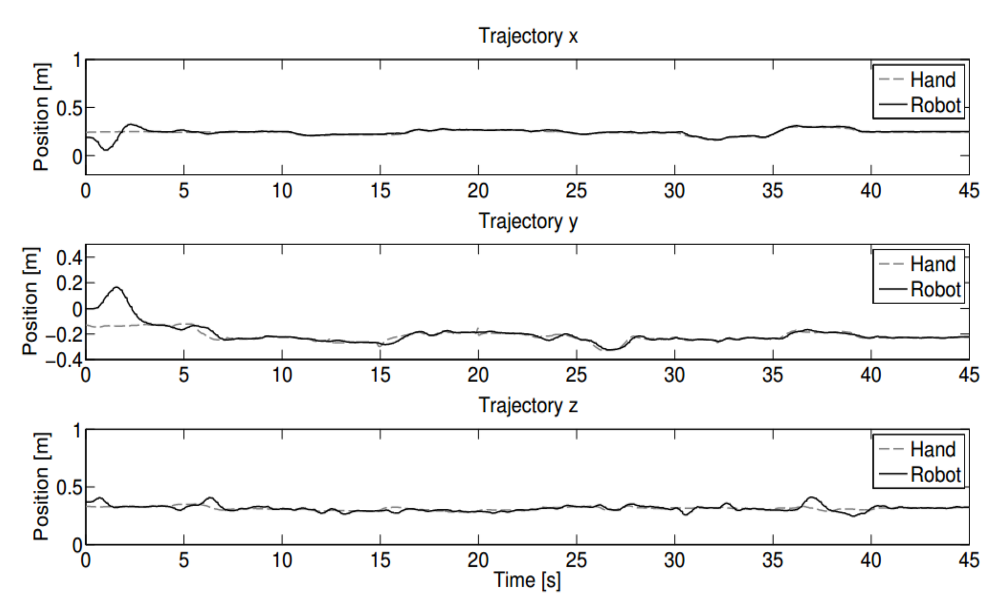
During shared control mode the robot has been capable on a total of **six trials** to execute always the **100%** of the path, except for one trial in which the **84.85%** has been achieved.

Results

Waypoints Following



Direct Control



[1] M. A. Goodrich et al. Experiments in adjustable autonomy. In IJCAI Workshop on Autonomy, Delegation and Control, 2001
[2] L. Almeida, B. Patrao, et al. Be the robot: Human embodiment in tele-operation driving tasks. In IEEE RO-MAN, pages 477–482, 2014.