TU WIEN Informatics

Mobile Collaborating Robots for Direct Haptics in Mixed Reality

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Problem & Motivation

VR headsets like HTC's Vive stimulate users' visual and auditory senses well enough for them to feel immersed in virtual environments. However, because of technological or cost limitations, most other human senses are neglected in current VR systems. To accommodate the feeling of touch aka haptics, a number of approaches exist, both as commercial products or ongoing research. To perform the task, robot-like hardware is typically installed to specific spots within the VR area and therefore location limited. Other equipment has to be carried around by users as exoskeletons or body-worn suits. This thesis proposes another concept, where users can move around freely with a minimum of body-worn equipment in a room-sized setup while a mobile manipulator is accompanying them to provide haptic sensations in arbitrary locations.

Goals

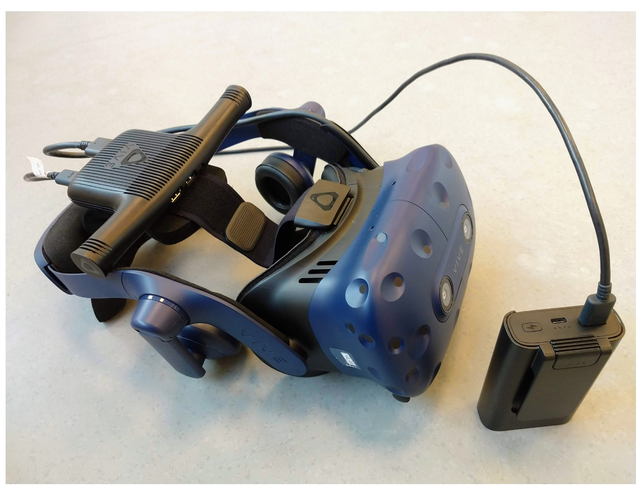
- Create a room-sized VR setup where users can move around freely
- Design a VR scene, where haptic sensations can be requested
- Extend mobile manipulator control logic to deliver haptic sensation to corresponding location in reality
- Open and exchangeable robot architecture

Tasks

- Implement control software to automate placement of prop
- Track robot location with VR hardware (Vive trackers)
- Mount physical prop on manipulator and extend robot description model
- Create VR application to deliver virtual and haptic experience

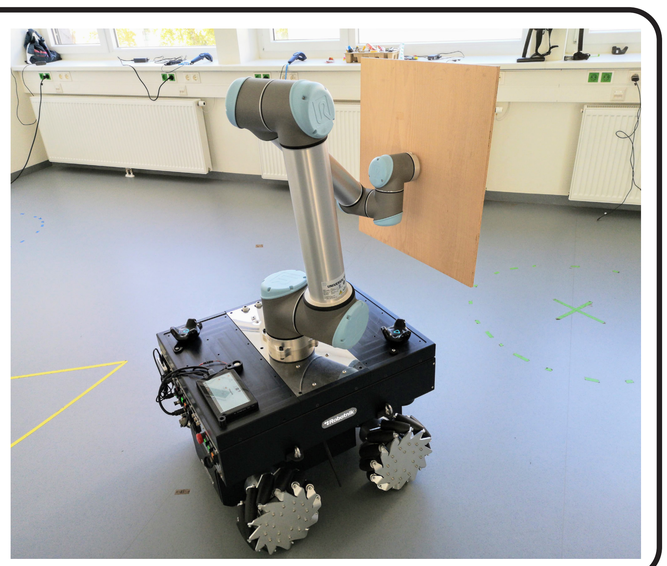
Vive Pro

- Virtual Reality headset from HTC & Valve
- Lighthouse tracking technology
- Max tracking area: 10 × 10 m with 4 lighthouses
- Wireless kit for unrestricted mobility of users
- Vive trackers allow tracking of arbitrary objects

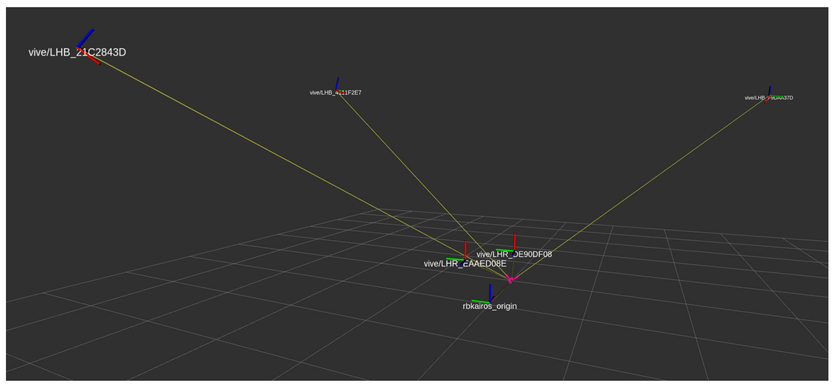


RB-Kairos

- Mobile manipulator from Robotnik Automation
- integrated UR-10 robot arm
- Dimensions: 0,89 × 0,56 × 0,83 m
- Mass: 100 kg rover & 29 kg arm
- Max speed: 3 m/s
- Mecanum wheels
- UR-10 payload: up to 10 kg
- UR-10 reach: 1300 mm
- Haptic prop: 0,6 × 0,6 × 0,01 m wooden panel



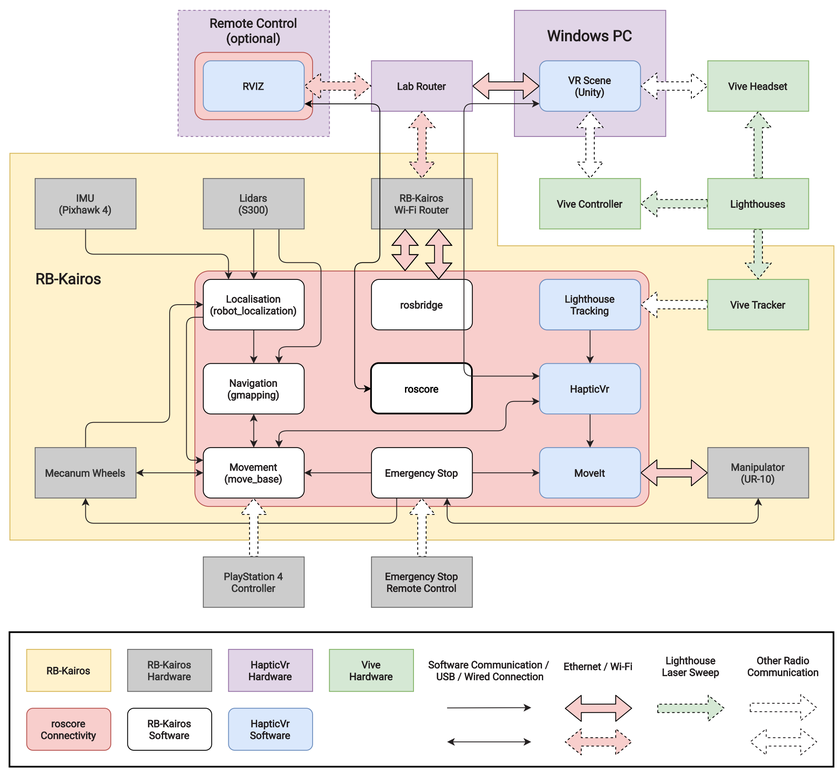
Lighthouse Tracking Of Robot



- Tracking area in VR lab: 8 × 6,3 m
- 3 lighthouses
- 2 trackers on robot
- Allows localization of robot in vive ecosystem

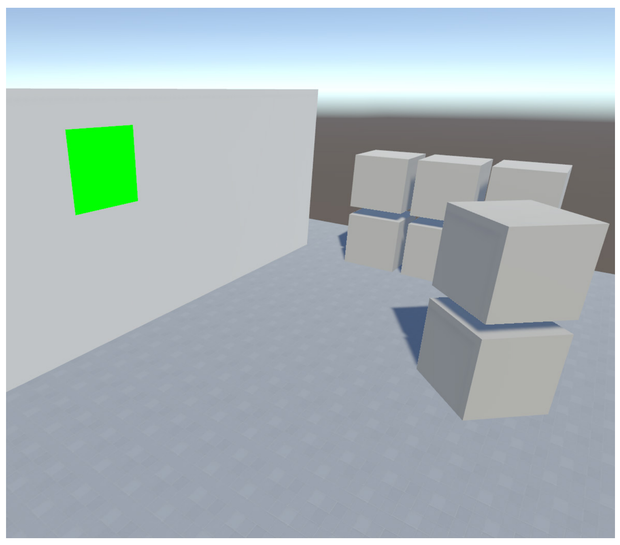
Robot Control

- Use Robot Operating System (ROS) to control robot functions
- Integrate preinstalled navigation algorithms into program flow
- Calculate robot position by tracking the location of lighthouse trackers
- Handle location of haptic surface from Unity application
- Implement routine to navigate robot to proximity of target location
- Use robot arm for fine-positioning of haptic prop on target location



VR Application

- Uses 3D framework Unity
- Track user's head position and render their point of view of virtual environment
- 2 types of interactive haptic objects: cube & wall
- Object surfaces can be chosen to provide haptic sensations
- Surface location is sent to robot for prop placement



Results

- Can deliver haptic experience in arbitrary orientations in a volume of 8 × 6,3 × 1,95 m
- Max duration of prop placement: 28 s
- Accuracy: +/- 0.01 m
- Robustness: robot weight (129 kg)
- Safety: force sensors in robot arm, laser scanners, emergency remote control