A *portable* da Vinci simulator in virtual reality

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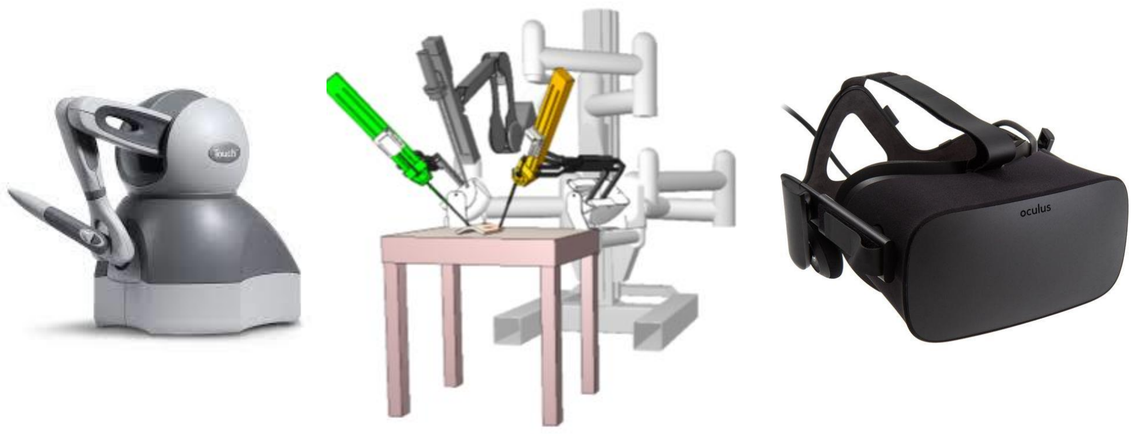
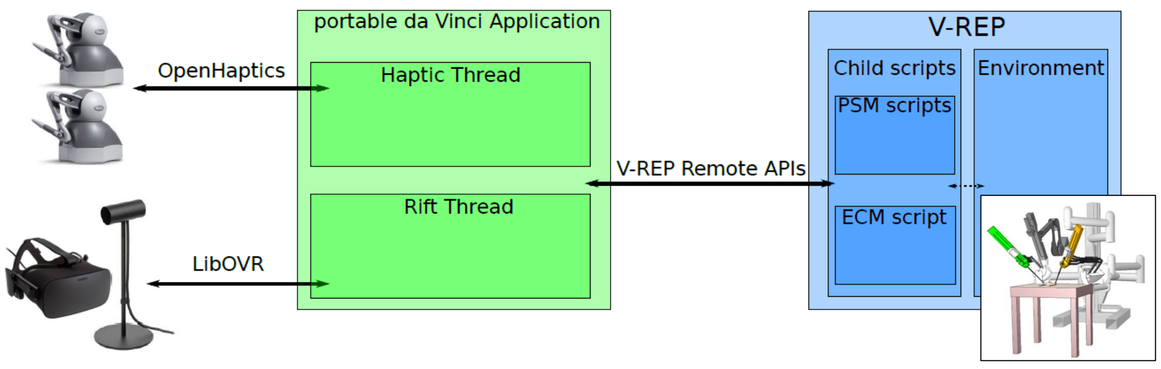
Motivation



The large diffusion of the master-slave da Vinci robotic system and the **da Vinci Research Kit** (**dVRK**) increased the use of **Minimally Invasive Robotic Surgery** (**MIRS**), along with the necessity to develop specific **simulation and training software** [1]-[3].

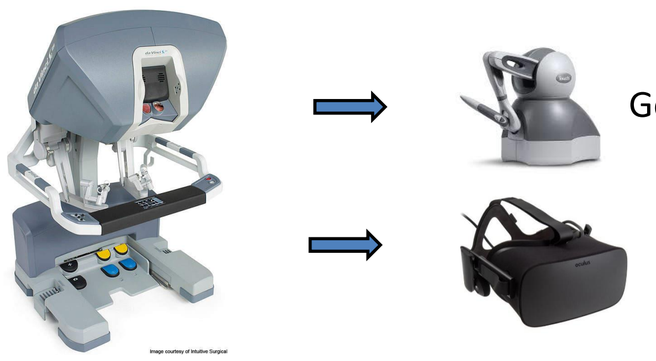
This work presents the complete open source dVRK simulator ([4]) which comprises a low-cost version of the Master surgeon console (i.e., **the Master Tool Manipulators** (**MTMs**) and the **3D vision system**), thus yielding a *portable* da Vinci simulated system. To this end, a pair of **Geomagic Touch** haptic devices and an **Oculus Rift** headset are employed.

Extending the Master Console



The **da Vinci Master console**:

- Sends commands to the **Patient-Side Manipulator** (**PSMs**) through the pair of **MTMs**;
- Shows **images** of a camera mounted on the **Endoscopic Camera Manipulator** (**ECM**) on a **3D vision system**



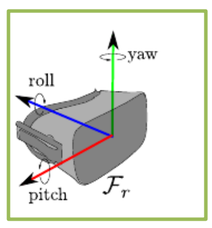
Geomagic Touch interface

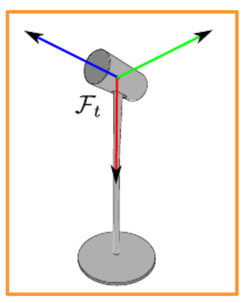
Oculus Rift headset

Image courtesy of Intuitive Surgical

Oculus Rift device connection

Oculus Rift
Head-Mounted Display

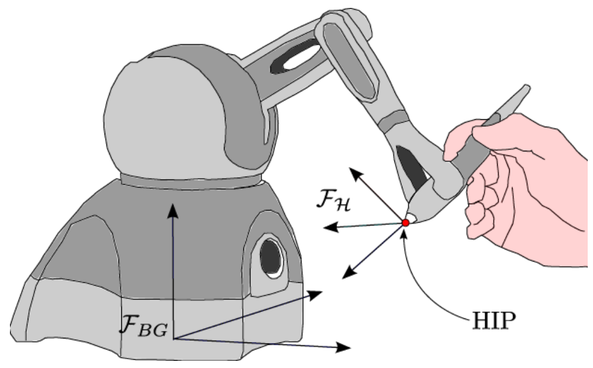




Constellation
Positional Tracking device

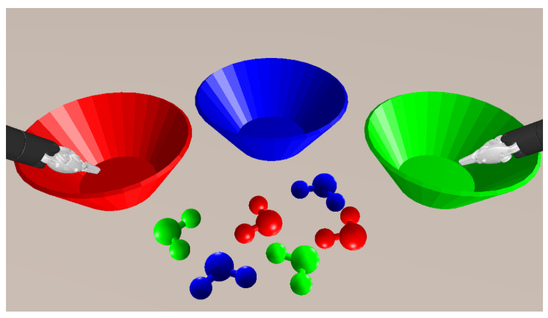
- **Oculus Rift Head-Mounted Display** (**HMD**) motion mapped to the 4-DoF ECM camera motion
- Decoupled control of camera orientation and translation along the optical axis

Geomagic Touch device connection



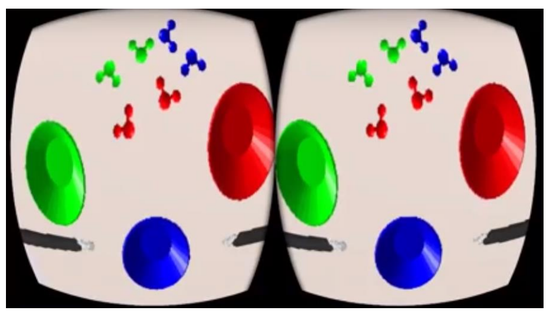
- **Geomagic Haptic Interface Point** (**HIP**) motion mapped to the 6-DoF PSM gripper motion
- **3-DoF Force Feedback** on the stylus to render **virtual forces**
- Functionalities based on stylus buttons pressure:
  - Clutch-based Master-Slave to account ***kinematic dissimilarity***
  - Object Grasping *(pick)* and Release *(place)*

Simulation

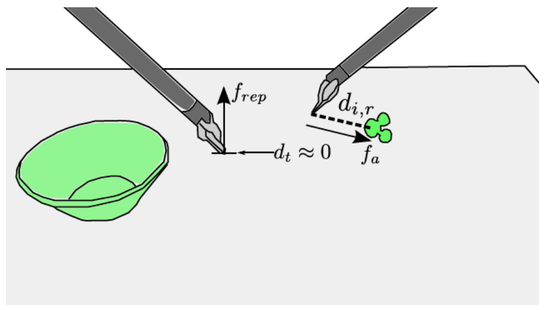


Pick-and-place training scenario.

Goal: grasp the colored objects to place in the corresponding cup



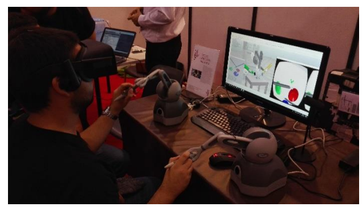
Virtual Reality:
Images acquired through the ECM cameras are shown in the **Oculus Rift HMD**

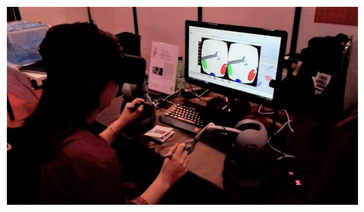


Haptic guidance with Geomagic:

- **attractive** force towards closer obejcts to assist grasping
- **repulsive** force simulating virtual contacts with the table

Tested to the **Maker Faire 2018 of Rome** by several non-expert users.





References

[1] A. Baheti, S. Seshadri, A. Kumar, G. Srimathveeravalli, T. Kesavadas, and K. Guru, "Ross: Virtual reality robotic surgical simulator for the da vinci surgical system," in *Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, 2008, pp. 479–480.
[2] "Mimic Simulation dV-Trainer." [Online]. Available: http://www.mimicsimulation.com/products/dv-trainer/
[3] "da Vinci Skills Simulator." [Online]. Available: https://www.intuitivesurgical.com/products/skills simulator/
[4] G. A. Fontanelli, M. Selvaggio, M. Ferro, F. Ficuciello, M. Vendittelli, and B. Siciliano, "A V-REP Simulator for the da Vinci Research Kit Robotic Platform," in *2018 7th IEEE International Conference on Biomedical Robotics and Biomechatronics (Biorob),* Aug 2018, pp. 1056–1061.